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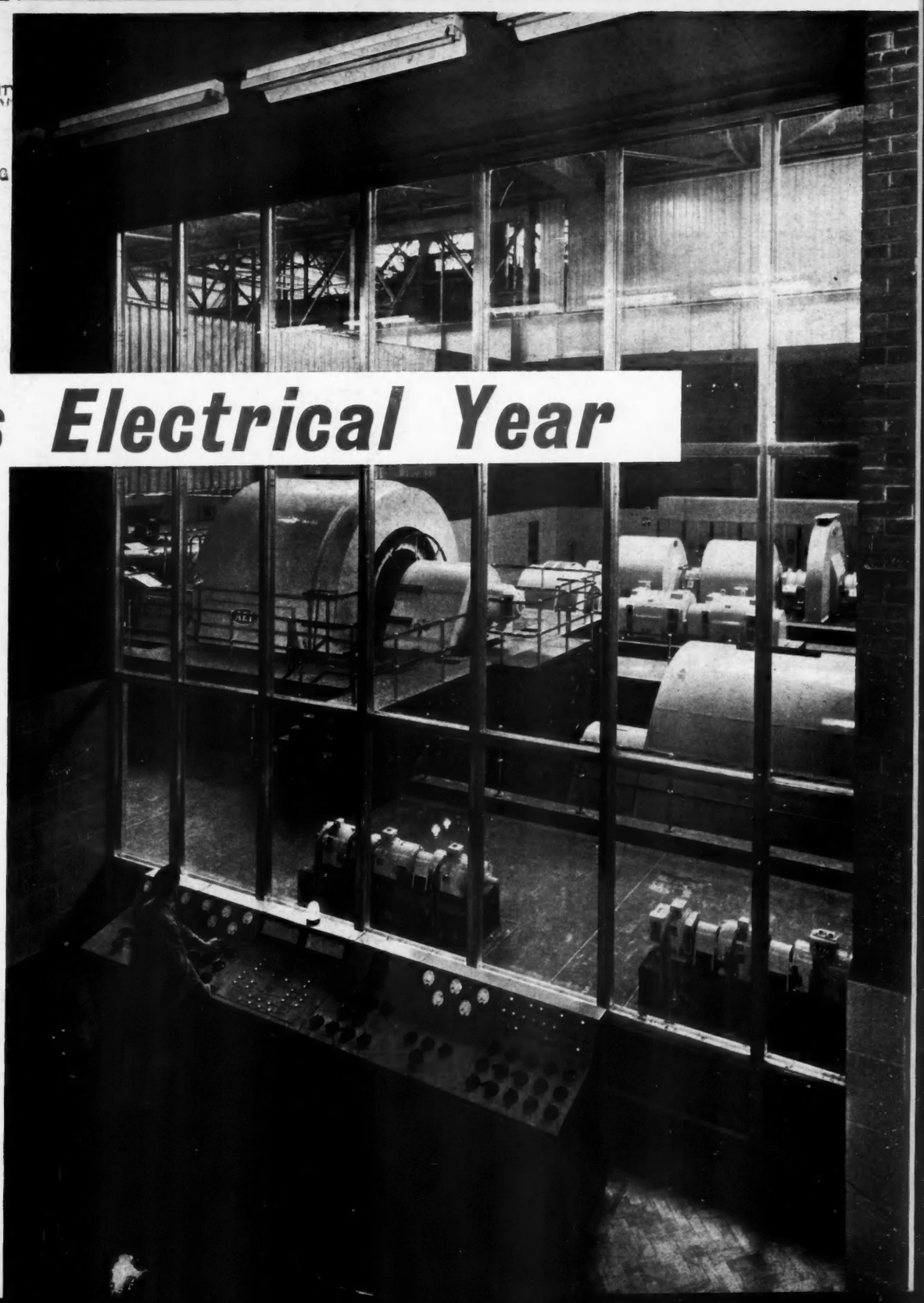

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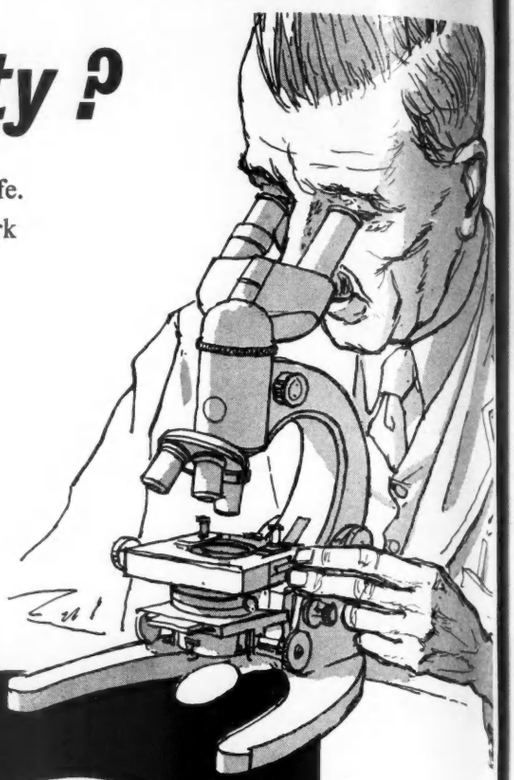
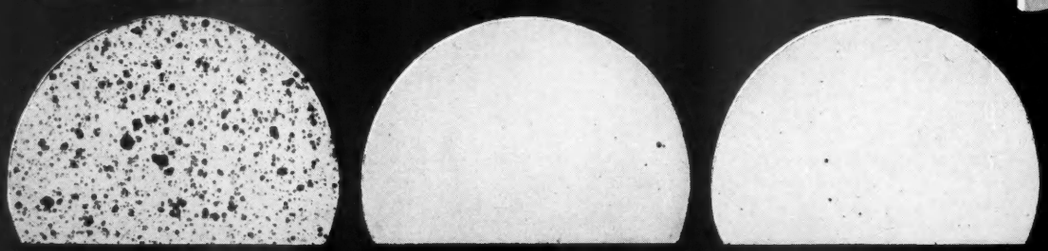
Many filters on the market do not, however. On test, they may start by showing a fair efficiency, but later, more and more of the abrasive particles pass through the filter material. Such unstable filters are quite useless, and are no safeguard to your fuel injection equipment whatsoever.

These photomicrographs of fuel tell the story of actual tests.



STABLE



1 Fuel laden with abrasive dust, before filtration

2 The same fuel after passing through a C.A.V. paper element filter at beginning of test

3 Fuel after filtration by the same element when all but choked by waxy sludge and dirt

UNSTABLE

4 The same fuel is used for this test

5 At the beginning of test, filtration is fairly efficient

6 After the filter element is partly choked, the fuel passing through takes with it nearly all the particles of dust

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Cover Picture

Power under control. The year 1961 has special significance for the electrical power industry: in particular its manufacturers celebrate the golden jubilee of their association and a massive export drive in the consumer field has been undertaken. Other landmarks include the completion of several nuclear power stations, the partial commissioning of the Ffestiniog pumped-storage scheme, and inauguration of the cross-Channel cable. ENGINEERING this week ranges from turbines and generators, through grid and distribution systems, to domestic and industrial consumers. The cover picture shows a 3,000 hp electrical drive for a steel mill.

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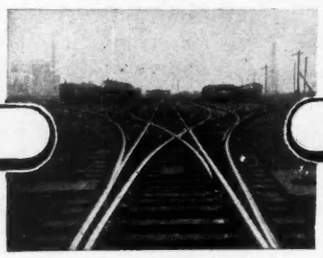

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ENGINEERING Impact

of the Swift Growth in Soviet Industry

WITH more British firms exhibiting at the 1961 Leipzig Spring Fair than ever before and with engineers and executives preparing to move off in battalions to the British Trade Fair in Moscow this summer it is worth looking at the industrial output figures of the annual report from the USSR's statistical office. They throw valuable light on the way in which Soviet industry is growing, where the opportunities lie and perhaps where some of the strongest competition will be coming from.

That the swing from the tooling-up phase of development to greater devotion to production of consumer goods is not going as fast as some commentators have in the past suggested, is made clear from the way in which capital goods output increased during 1960 by 11 per cent while production of consumer goods rose by 7 per cent. Overall industrial output for the year is given as increasing by 10 per cent.

The basic industries were all advancing steadily. Pig iron output rose from 43 million tons to 46·8 million, crude steel from 60 million tons to 65·3 million, iron ore from 94·4 million to 107 million tons. While coal production was more or less the same—513 million tons against 1959's 507 million, the movement towards greater use of oil and gas was clearly shown by the jump in oil production from 129·6 million tons to 148 million. Gas output went up from 37·3 to 47 milliard cu. m, electricity from 265·8 to 292 milliard kWh. (One milliard = 10^9.)

Chemicals Opportunity

These are the broad background movements underlying the Soviet economy. An important sector worth close examination is that of chemicals and chemical machinery.

Annual production from the chemical industry grew by 12 per cent, a sizeable increase but not up to the pace of advance proposed in the seven year plan. Chemical equipment, although production rose from a value of 175 milliard roubles to 224 milliard, was also seen as an industry not fulfilling its part in the planned scheme of things.

If the chemicals industry, in as strategic a position for the whole operation as iron and steel or transport, is lagging behind, then there is more than usual reason for vigorous representation of what the United Kingdom's chemical industry can assist with, and what the their machinery makers can provide.

Mr. Khrushchev and other leaders have made plain what a sorry tale is 1960's agricultural story. On the agricultural machinery side there has been solid advance, tractor production is up from 213,500 to 238,500, which is proportionately a much higher rise than in cars and lorries, which only in 1960 passed the half million mark. Tractor cultivators have been reduced from 121,500 in 1959 to 83,500 last year.

Whether the Soviet Union could be made a large and receptive market for Britain's agricultural machinery, after the fashion set by Yugoslavia and to a limited degree by China, is not an easy thing to determine. What is sure is that just as labour productivity in industry is said to have risen by 5 per cent, a necessary corollary to the reduced working week, so there is a profound need to make a major improvement in the productivity of the agricultural worker—and that means more mechanisation.

The general picture of the report is one of a country moving steadily towards higher output per man at a pace which should bring the Soviet Union within the orbit of the high personal consumption nations in a very few years. The ramifications whether for East-West trade, or for the ideological struggle, or even simply for disarmament will be as great as the domestic implications for the Russians.

New Naval Planning Brings Shipyard Orders

There is a double significance for British shipyards in the recently announced plans for new equipment and at least one new style of ship for the Royal Navy.

The two additional guided missile destroyers and the assault ship to be built are all valuable contracts for one yard or another. They hold out the promise of keeping the skilled labour force together and of carrying the overheads on a greater work load. And the new assault ship, capable of sinking down into the sea by flooding compartments and so launching landing craft, is not the answer to a specially Royal Navy problem. It is not to be ruled out, when this multi-purpose unit is in service and demonstrating her capabilities, that the defence ministries of other powers may not consider adding some such versatile vessel to their own navies.

Each of the guided missile destroyers to be added to the four already ordered is likely to cost more than £3 million, a useful addition to order books which still fail to grow at a pace equal to that of the tonnage being completed and launched.

Helicopter Uses

Clearly underlined by the Navy Estimates and the explanatory guidance accompanying them is the extent of the Royal Navy's use of the helicopter; for carrying marine commando parties behind enemy lines, for submarine hunting, and for submarine killing with the homing torpedo. The new Leander and Tribal class frigates are to be equipped with Westland P531's, light torpedo carrying helicopters. This will extend the range of the frigates and the speed with which accurate attack can be mounted to a degree which constitutes a substantial advance in the Royal Navy's anti-submarine potential.

For the big brother of the modern fleet, the aircraft carrier, there has been no announcement of a new carrier programme, but there has been some interesting indication of the time scale in these moves—given by Lord Carrington, the First Lord of the Admiralty. It is estimated that the present generation of aircraft carriers will be reaching the end of their useful lives in the early 1970's. Plans have been made concerning the best kind of replacement, this is in order not to waste time when advice has to be given on the decision to build. Inevitably this has led to some speculation and it has taken the line that perhaps next year's estimates will bring with them news of plans for the first of the new carriers, perhaps with a commissioning date somewhere in the mid-1970's.

of Oil as the Spur to Mine Mechanisation

Starting at the end of March the National Coal Board launches out on the most intensive and wide-spread mechanisation programme yet undertaken in the coal mining industry.

At the same time the Board is getting into its stride with what may be termed consumer appeal, extending all the way from blending coals to give the similarly exact burning characteristics readily available from oil fuels to wooing the housewife with easy payments.

At the beginning of the mechanisation drive, the mining industry loads about 40 per cent of its coal by mechanical means. The target is to raise this to 80 per cent, an aim which Mr. Alfred Robens, the NCB chairman, justly told the recent annual dinner of the Institution of Plant Engineers to be the source of tremendous technical difficulties.

To the optimists who observe that there is far more coal under the United Kingdom than has been brought up in all the history of the mines, the pessimists have replied that many of the best seams have been worked out that the Coal Board was spending more and more grinding away at less and less remunerative seams. To this, of course, there are several categorical replies, not the least among them being the £14 million mine at Cynheidre in South Wales with its immense future output of high value anthracite.

Clean and Blended

The engineering reply to the pessimists is to devise machines capable of exploiting seams which for one reason or another cannot be tackled by the old methods. Mr. Robens particularly mentioned to the Plant Engineers an experimental machine which utilises the back scatter of gamma rays for accurate control while working in seams too confined for miners to work there.

The 80 per cent mechanically loaded target is one the Board hope to have hit by 1965. Selling coal against competition from oil—itself in world surplus—means that price is an essential element, and the NCB expects its mechanisation to assist in holding the price level. Just after setting out on the intensified mechanisation campaign, the NCB is to open what Mr. Robens describes as the biggest sales campaign ever carried out in the history of mining. This is not only going to be a matter of persuasion, of reminding the consumer that coal exists, is a native fuel, and so on.

Oil fuel has the decided benefit that its consistent performance is predictable, and certain. Coal not only comes from different collieries, its performance as a fuel may change as the machines work along the seam. So far, the NCB has around 270 plants cleaning and blending coal. Another 50 are being built, and they will bring the Board's capacity in cleaned and blended coals up to 140 million tons a year, two-thirds of the probable annual demand in the near future.

Millions of tons of the Board's low grade coal goes to the furnaces of the power stations. Five million tons each year will be going to the new 2,000 MW West Burton station, near Gainsborough on the river Trent, for which the Minister of Power gave permission this week. To cost between £50 million and £60 million, West Burton will be one of the world's most powerful steam power stations.

Mr. Robens is a realist in his view of the inevitability of the battle with oil. The sharpness of the battle has galvanised the Board into a state of awareness of the customers' needs, whether industrial or domestic, that is of a quite new order. Mr. Robens tells the Plant Engineers that with energy and drive the industry will be maintained as the largest in the country. Under the new conditions it offers to engineering a number of challenges as rewarding as those of younger more romantic industries.

and Greater Power for Southern Spain

The capacity of the Cadiz power station in Southern Spain, now 60 MW, is to be slightly more than doubled, by another 62 MW, when a third generating unit to be paid for by a credit from the United States Export-Import Bank of Washington is installed.

The Spanish governmental Instituto Nacional de Industria (INI) is the agency through which the Export-Import Bank is providing the $8·7 million credit (£3,107,000). Westinghouse International are to supply the power generating equipment. Boilers and related equipment will be provided by another United States concern.

The limited rainfall of Andalusia reduces the possibilities of hydro-electric development, making thermal stations the most practical. Although the station has been designed to use oil, gas or domestic coal, whichever offers the most economical operation, present plans are that coal will be used.

Southern Spain, where Sevilla, Cordoba and Malaga are among the centres of power distribution, has a growing electricity demand. Eximbank's £3 million credit has a repayment period spread over 12 years, though not beginning until 1964.

These terms will not be lost on the Federation of British Industries' trade team who have been touring Spain. Britain is the largest single buyer of Spanish exports and conversely Spanish purchases from the United Kingdom have been rising, though only at a fraction of the rate of the trade in the other direction.

At least one major British group has a lively subsidiary operating in the Spanish transport industry, standing to benefit from the increased industrial activity made possible by stepping up the power output. But if the British heavy electrical equipment manufacturers are to compete with what in effect is a 15 year credit from the Eximbank, it may be that some directly comparable British export financing bank will have to be set up.

What Steels Next in Power Generation?

Ferritic steels are vital to power generation, but demand careful design to avoid failures. Some alloys deserve far more development work.

ADVANCES made in high-temperature high pressure steam power plant for electricity generation have owed a lot to use of ferritic alloy steels for vital components. The range of these steels is shown in the table, along with types of component for which they are either now being used or for which they are proposed. Below, you can see the large amount of alloy steel used in a typical 200 MW station.

271 tons	Superheater tubes and headers
57 tons	Reheater tubes and headers
140 tons	Pipework
133 tons	Turbo generator

While most of these materials were developed specifically for the power industry, several were used initially for such requirements as tubing in oil refineries and turbine discs in aircraft.

Development of these materials has been continuing for 30 years, beginning with the ½Mo-steel (1) and 1Cr-Mo-steel (2)—the figures in brackets relating to those in the table—for the advanced steam temperature conditions of 900° F in the period immediately preceding 1939. After the gap of the wartime years, most effort involved addition of such elements as molybdenum, vanadium, tungsten, titanium and niobium, to either a mild steel base or one containing 12 per cent chromium. Other steels, such as the 2¼Cr-1Mo-steel (8) and 3Cr-Mo-V-W-steel (11) compositions, were adopted after successful use in other industries, and this approach is again implied in recent suggestions to use the 9Cr-Mo-steel (14) for boiler reheater tubes.

During the past decade, emphasis has been taken off high creep strength as the sole criterion for selection; it is now realised that the low ductility associated with high creep resistance can lead to cracking in welds. Thus a compromise must be sought between strength, weldability and corrosion resistance. In view of wide scatter in high temperature test properties, a great deal more creep testing must also be done.

The ½Mo-steel (1) and 1Cr-Mo-steel (2) have been used for various components for about 25 years. But some troubles have been experienced with the former: for instance, cracking has occurred in superheater tubing, superheater headers, steam pipes and turbine casings. It is now appreciated that these failures were closely associated with high residual stresses, which, in a material of comparatively low plasticity, could not be relieved without cracking taking place. The extent of these residual stresses is difficult to measure, one of the most successful methods being the use of X-ray diffraction.

Recent American work has shown the need for controlled heating and cooling rates in operating turbines if cracking problems are to be avoided. It is concluded from this work that for ferritic steels these rates should not exceed 400° F per hr while the temperature differential across the section of the component should not exceed 150° F.

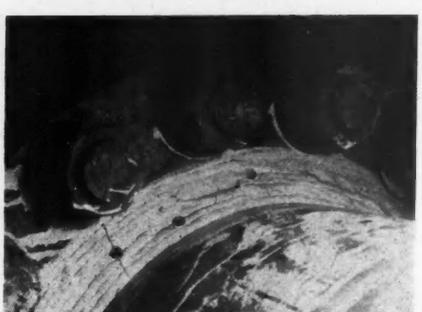
The 1Cr-½Mo-steel (2) used for superheater and steam pipes has been comparatively free from cracking troubles. Service experience with 2¼Cr-1Mo-steel (5) and ½Mo-V-steel (4) has been more limited but is, to date, satisfactory. The main difficulty which has arisen in using some of the vanadium bearing low alloy steels has stemmed from cracking experienced in the heat affected zone of welds which has been observed both during construction and after periods of service. An associated problem in these materials is the difficulty of making repair welds on complex shaped components: this has been noted, for example, with the 3Cr-Mo-V-W-steel (9) when used as a casting.

Ferritic Alloy Steels (see Numbers in Parentheses in Text)

No.	Steel type	Nominal analysis, per cent								Power plant application	Initial industrial use
		C	Mn	Si	Cr	Mo	W	V	Ti		
1	½Mo	0·1	0·6	0·25	—	0·55	—	—	—	Superheater tubes, steam pipes, valves, turbine components	Steam power plant
2	1Cr-½Mo	0·1	0·5	0·25	1·0	0·5	—	—	—	Superheater tubes, steam pipes	Steam power plant
3	1Cr-½Mo	0·4	0·6	0·25	1·2	0·6	—	—	—	Boltings up to 900° F	Steam power plant
4	½Cr-½Mo-¼V	0·1	0·5	0·25	0·35	0·6	—	0·25	—	Steam pipes, turbine casings, turbine rotors	Steam power plant
5	1Cr-1MO-¼V	0·16	0·6	0·25	0·9	0·9	—	0·3	—	Turbine rotors, casings	Steam power plant
6	1Cr-1Mo-¼V	0·2	0·6	0·25	1·1	1·0	—	0·7	—	Bolting above 900° F	Steam power plant
7	1Cr-1¼Mn-½Mo-¼V	0·17	1·5	0·3	0·7	0·3	—	0·1	—	Pressure vessels	Steam power plant
8	2¼Cr-1Mo	0·1	0·5	0·4	2·25	1·0	—	—	—	Superheater tubes, steam pipes, valves	Oil refineries
9	2½Ni-Cr-Mo	0·3	0·5	0·25	0·7	0·4		Ni 2·5		Generator rotors	General engineering
10	3Cr-Mo	0·3	0·5	0·25	3·0	0·5	—	—	—	Generator rotors	General engineering
11	3Cr-1Mo-¼V-W	0·23	0·3	0·45	2·7	0·5	0·5	0·25	—	Turbine casings, valves, bolting above 900° F	Aircraft gas turbines
12	7Cr-Mo-V-W-Ti	0·1	1·0	0·5	6·0	1·0	0·5	0·2	0·3	Experimental	
13	8Cr-3Mo-1Ti	0·05	0·6	0·75	8·5	3·0	—	—	1·25	Experimental	
14	9Cr-1Mo	0·1	0·5	0·75	9·0	1·0	—	—	—	Reheater tubing	Oil refineries
15	12Cr	0·08	0·45	0·3	12·5	—	—	—	—	Turbine blading	Steam power plant
16	12Cr-Mo	0·1	0·6	0·3	12·5	0·75	—	—	—	Turbine blading	Steam power plant
17	12Cr-Mo-V	0·1	0·6	0·3	12·0	0·6	—	0·15	—	Turbine blading, rotors, superheater tubing	Aircraft gas turbines
18	12Cr-Mo-V-W-Nb	0·2	0·5	0·4	12·0	1·0	0·5	0·3	—	Turbine blading, rotors, superheater tubing	Aircraft gas turbines

Operational experience is now being accumulated with the 1Cr-1Mo-¼V-steel (5) in high pressure rotors and with two bolting materials, a 1Cr-1Mo-¾V-steel (6) and a 3Cr-Mo-V-W-steel (11). In these cases a compromise has to be sought between hardenability and creep strength requirements. Increases in turbine size and severity of operating conditions make this compromise harder to obtain for high duty rotors. The chief need in bolting materials is to avoid notch sensitivity as strength is raised.

The advent of more onerous conditions in the turbine has led to use of complex 12Cr-steels (16, 17, 18). This may be for greater creep strength requirements in the high pressure rotor, or to provide the necessary combination of mechanical properties and corrosion resistance being demanded by the large blades at the exhaust end of the low pressure rotor in the 275 MW and 500 MW turbines now under construction. There is not, as yet, much service experience of these materials in this country. On the Continent, however, these 12Cr-steels have been used for turbine rotors and casings.



A fillet weld at a superheater header flange. The flange was in 1Cr-½Mo-steel welded with ½Mo-steel. Note that the notch effect of the weld metal layers has lead to transverse cracking, and residual stress in the weld itself has lead to circumferential cracking. Movement of the header during heating and cooling of the boiler contributed to failure. This illustrates the effect of detail engineering design on material and weld performance. (Holes were drilled after cracking had taken place.)

Corrosion resistance of these materials is largely a function of their chromium content. Laboratory and field tests in air, steam and flue gas atmospheres have shown that, for metal temperatures up to about 1,050° F, a chromium content of 2 to 3 per cent is adequate, but that above this temperature at least 7 per cent chromium is required. In consequence of this, steels (12, 13) of such a chromium content have been developed, but for a variety of reasons, some technical and some economic, they have not yet found commercial application. Service experience with 1,050° F steam power stations confirms the predictions of these laboratory tests, but has shown the need for more knowledge of the corrosion resistance of valve materials.

This need for further knowledge extends to the hottest sections of the superheater and reheater. This aspect is also influenced by the types of coal used for firing the boiler. In this respect there may be justification for pursuing development of 12Cr-steels in the last stage of superheaters.

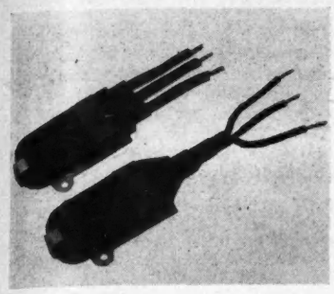
In the power plant industry capital investment increases annually, but the number of power units is falling: in this situation material assessment must be as reliable as humanly possible. Some of these materials are, and will be, ferritic alloy steels of the types mentioned in this article.

Possibly in the past too much of the onus for successful development of materials has been placed on the steelmaker, who has no direct control over procedures such as welding and stress relieving which vitally affect properties. It is also unfortunate that in recent years too many materials have been in the experimental stage at one time, none of them receiving the volume of development work necessary to bring it to fruition. Rationalisation of materials would be a very good thing at this time.

This article is based on a more comprehensive treatment by Mr. M. G. Gemmill of the Central Electricity Generating Board which appeared in the December, 1960, issue of *Alloy Metals Review*, published by High Speed Steel Alloys Limited of Widnes, Lancashire.

Neoprene Covers for Circuit Breakers

Du Pont claim that the introduction of neoprene synthetic rubber as an insulant and protective covering for a French industrial circuit breaker is a significant advance. The new breaker, called the Minirupteur, has the advantage of being



completely insulated where previously it had been difficult to provide sufficient protection for the delicate mechanisms of these high-precision electrical contacts.

The system of make-and-break is based on a thin S-shaped metal plate which resists shocks and vibration. The metal case of the breaker is protected by a neoprene cover which enables it to function in dust-laden atmospheres, in oils, water and chemicals.

These circuit breakers are used in a wide range of applications including automobile gear boxes, automatic foundries, steelworks, industrial and domestic washing machines and mechanical handling equipment. They must therefore withstand many different atmospheres, weather, water vapour and ageing. Previously, moulded plastic materials had been used. The circuit breakers are now said to have longer lives and require less frequent replacements.

Minirupteur circuit breakers by Société SERMEC, 18 Rue Jean-Jacques Rousseau, Valence, France.

Crack Detection Inks and Powders

Southern Tools, who are well known as manufacturers of penetrameters for industrial radiography, announce a new range of magnetic inks and powders for magnetic crack detection.

Two inks are available: black-grey high sensitivity, and fluorescent. They are supplied in concentrated form in quantities to make 1 gallon. This avoids sedimentation during storage, say the makers, and the inconvenience of handling large containers. To make the inks, all that is necessary is to warm the container gently till the contents melt, and then pour the contents into a gallon of water. The container can be rinsed into the water so that there is no loss of the contents; the resultant mixture is then agitated in the usual way.

The advantages of using water as a medium are that it is non-inflammable, has no disagreeable smell, is clean to handle and does not have adverse effects on the skin; in the concentrate are carefully adjusted amounts of additives to ensure that the specimens will not rust, that the ink will flow readily over slightly greasy surfaces, and that a proper rate of sedimentation takes place.

Southern Tools can also supply a replenisher, if their customers wish to top up their ink containers; plain water should not be used for this purpose as it will change the characteristics of the ink.

The black/grey ink is highly sensitive, and is claimed to contrast well on both bright and black surfaces, looking black on bright surfaces and light grey on black surfaces. The fluorescent ink is necessarily less sensitive than the black-grey, but tests show that the sensitivity is still very good. The ink gives a clear bright glow under ultra-violet light. Care has been taken to avoid as far as possible the nuisance of background glow.

The powders are available in 1 lb tins in black, grey and copper red. The red coloured grains give good contrast, and are very little less sensitive than the others; if they are viewed in a bright light, the glinting effect adds to the ease of recognition.

Southern Tools Limited, 22 Upper Mulgrave Road, Cheam, Surrey.

Proofed Nylon Wagon Sheets

Following the widespread success of coated nylon fabrics for dozens of uses from salvage sheets to flexible containers, say British Nylon Spinners, they are now being considered for railway wagon sheets. This illustration of an experimental sheet produced by Lea Bridge Industries from Hydex 504 (5½ oz low twist nylon base cloth coated with pvc to a total weight of about 16½ oz per sq. yd) demonstrates clearly how the flexibility of nylon sheets makes them easy to handle. They fold into a compact bundle even when wet.

They are completely waterproof and, furthermore, remain relatively light in weight whereas a conventional sheet which has been in use for some time may double in weight as a result of

redressing. Additional attractions are nylon's toughness, durability and immunity from rotting.

British Nylon Spinners Limited, 68 Knightsbridge, London, SW1.

Aluminium Fishroom

Motor trawler, "Captain Foley," the latest addition to the fishing fleet of the Iago Steam Trawler Company, is now undertaking her first sea voyage. Like many modern vessels, the Captain Foley makes wide use of aluminium—above decks for deck pounds, wheelhouse bridge, funnel and other parts of the superstructure, below decks for fitting out the fishrooms.

Iago were the first British trawler owners to exploit the advantages of aluminium in their fishing fleet. More than 10 years ago, the trawlers "Red Rose," and "Red Hackle" used the light metal extensively—for fishroom linings and shelf boards, deck pound boards and parts of the superstructure.

But this was not the first of Iago's pioneering efforts. As far back as the 1920's they collaborated with the Department of Scientific and Industrial Research to find a more durable and hygienic material than the traditional wood for fishroom linings and shelf boards.

In 1930, the fishrooms of the new Iago trawlers "Admiral Sir John Lawford" and "Red Gauntlet" were lined with Monel metal sheet. This experiment, the first of its kind, was completely successful and Iago hoped that the same material could be used for shelf boards. Difficulties were however, encountered in fabricating Monel metal into the shapes required; galvanised iron was tried instead, but added weight was a big disadvantage.

It was not until after the war that a full-scale effort could be made to introduce all-metal fishrooms. Monel metal was in very short supply, so stainless steel was used to line the fishrooms in four ships. Again difficulties in working the metal proved a handicap.

It was at this time that Iago were introduced to aluminium. ICI Metals Division recommended an aluminium alloy sheet which had all the required characteristics of strength, durability and ease of working; moreover, it was lighter in weight than any metal tried so far. This proved the ideal material for fishroom linings and since then Iago have found nothing better.

ICI also produced an aluminium alloy suitable for more complex fabrication, and close collaboration between the two companies resulted in the design and manufacture of extruded shelf and pound boards which, after test, were installed in the trawlers Red Rose and Red Hackle, built by John Lewis and Sons of Aberdeen, in 1949-50.

Imperial Aluminium Company Limited, PO Box 216, Witton, Birmingham 6.

Glass Fibre Tissue Paper

A series of new applications are demonstrating the ability of Tissuglas—an all glass insulating paper—to solve unusual electrical thermal and electrical problems.

Tissuglas is a sheet of matted submicron glass fibres made on a specially adapted paper making machine by American Machine and Foundry Company. It is uniform in texture and electrical resistance, and has very unusual properties as an insulating material; melting temperature is above 1,200° F; thickness can be from ultra-thin (0·0006 in) to 0·012 in; pore sizes are from 8 to 90 microns; and dielectric strength is 370 to 2,370 volts. It is produced in any width up to 38 in, in continuous rolls.

The newest, and potentially largest application of Tissuglas is as a base for electroluminescent lamps, say the makers. These lamps are flexible panels as thin as $\frac{1}{16}$ in. The resulting lamps are said to give the brightest, clearest and most uniformly texture light of any electroluminescent panels on the market today.

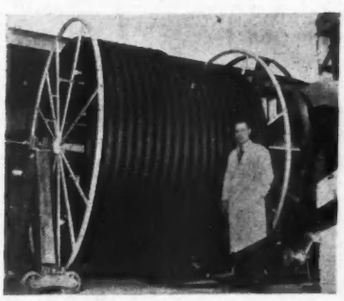
Another application of Tissuglas is in manufacture of bonded strain gauges. Tissuglas, in this application, is used as a saturating base, and its ability to pick up resins in uniform thickness (a function of its patented floc-free matting) gives the gauges uniform resistance and high temperature stability.

Tissuglas is also finding a new market as a component for printed circuit materials. In this use it is laminated with a very thin copper foil. As an example, 0·001 in thick Tissuglas together with a 0·00075 in thick copper produce the thinnest and most flexible printed circuit material now available.

AMF Limited, 4-6 Saville Row, London, W1.

Polyethylene Hose

In a factory at Roubaix, France, two lengths of polyethylene tubing, each 750 metres long, have



just been completed. The diameter is 110 mm, and it is said to be the first time in Europe such a quantity of this type of tubing, of such diameter, has been produced. The lengths are mounted on two giant bobbins and will shortly be leaving for Cannes. They will be used for piping drinking water to the Iles de Lerine and Sainte Marguerite.

Plain Words

By Capricorn

POWER, of one kind or another, is the key to all achievement, good or bad. And it seems to me that in failing to recognise the pre-eminence of electric power in technical development we have mistaken our priorities.

I often think what miracles could be wrought if power were plentiful, unlimited. A change in the availability and cost of power would revolutionise our way of life. Power represents so great a fraction of all the things we buy, from the cost of refining the aluminium in our saucepans to the cost of pumping water to our taps, that even the most trivial aspects of our lives would be affected. The costly, kilowatt-hours available today hardly serve to warm us in the winter time.

Power level, as Watt and the Industrial Revolution demonstrated, is our basic industrial limitation, and our only hope of overcoming it is currently frustrated by lack of public interest—all on account of a single disappointment. Because of an embarrassing and premature release of information, the United Kingdom's thermonuclear effort has faded into the background. One major project has even been abandoned. Meanwhile, in Australia, at the University of Sydney, a chair of thermonuclear power has been established. And already the Americans are claiming—though very quietly—to have detected neutrons from a thermonuclear reaction.

It has been argued that the successful exploitation of fusion energy could not in any case reduce the cost of power very much: the separation of the fuel, deuterium, from water is, I gather, an avidly energy consuming process; and it is the cost of distribution, rather than the cost of generation, that raises the price of power to the consumer.

On the other hand, since energy is the prime requirement for the separation process, and indeed for every other industrial purpose, including the capital construction of power plants and distribution systems, the effect of energy feedback to the processes of energy production may well bring cumulative economies. An entirely novel situation might arise, in which limitations other than energy supplies predominated.

A single setback has sent us looking for prestige in new directions, while the greatest technical problem of our times apparently remains neglected.

Admittedly, there are more immediate questions to be answered. Too often effort has been concentrated on developing a weapon that would win the war, when what was needed was a weapon to win the next engagement. But this time it is a different kind of war, and we are preparing for the wrong one. It is time we took another look at our priorities, for thermonuclear power is the vital factor.

Solve this problem, and you have solved them all.

Letters to the Editor

Off-Peak Heating

SIR, From your Outlook 1961 article on " Power Plant and Prime Movers " (ENGNG., 20 Jan. '61, p. 114), dealing with electric supply and pumped storage to flatten the peak I take the following quotation (abridged): " perhaps the first glimpse of a break through in finding a solution to the problem of better utilisation of the enormous capital investment in generating plant in Britain, now running at £300 million a year, and increasing until it may become the largest single capital investment item in the whole national budget; there is a pressing need to improve the load factor beyond the figure of about 47 per cent " (p. 117).

We must have sufficient installed capacity to meet the maximum demand, which, as your review points out, is increasing at roughly 10 per cent per annum. But more effective use of existing plant could surely be made by a vast extension in the off-peak heating of buildings; so obtaining a great saving in our natural heat resources now so sadly squandered.

I believe it was through the energy and drive of Mr. Gerald Nabarro that new industrial buildings must have a minimum standard of thermal insulation. Unfortunately, this does not apply to housing. Proper thermal insulation, built into the design, not tacked on as an after-thought at the separate expense of the purchaser, must go hand-in-hand with electric storage heating if this is to be an economic proposition.

Three years ago, I planned an all-electric bungalow (architect: Mr. W. T. Glare, A.R.I.B.A., of Leamington Spa) with sealed cavity walls, inner leaf thermal blocks, outer leaf brick, double-glazed windows, Stramit roof, thermal-acoustic ceilings, solid concrete floors with embedded heating cable: the lot. Then the developers got to work and my one-man Clean Air Act came to nothing. I am surrounded by hundreds of puffing chimneys, burning soft coal in open fires. This is called " giving the people what they want." The only " improvement " in these Victorian designs is that the coalhole in the pavement now becomes a bunker in the yard. Dirty coal is humped round the district, carried into the homes, and the ashes carted away (for which I pay rates). A thoroughly inefficient and dirty business from beginning to end. The oil truck calls at less than one in a thousand of these places. The pre-war rate of house building was 1,000 a day. I don't know what it is now, but this I do know: millions of these " slums from the start " are springing up all over the country, and we shall have to live with them for another century.

There is no coordination. The National Coal Board is presently running a national advertising campaign to perpetuate this kind of thing. The electric interests, if asked, would say that the proper place to burn coal is in power stations, by the ton. No use pushing up operating temperatures and pressures in bigger units in base load stations to improve that 30 per cent, if the bulk of the material is wasted outside. It is conceded that railways, if we must have them, must eventually be electrified (the Swiss did that in 1912) and the same should apply to home heating. We are long past the stage when every factory and mill had its own steam engine, distributing power by belt and pulley. If anyone comes up with the old " strategic " argument on the folly of putting all essential services in one basket, that situation changed 16 years ago with the first A-bomb. It's all or nothing now.

At present, too much is left to the individual Area Boards: some are alive and go out to drum up business (Woking has 46 all-electric houses in a clean-air colony). With others, you have to bang on the door before they produce the off-peak tariff (they had it all the time) and then they sit back and watch the gas, coal, and oil interests beat them to it, and how!

Let us hasten the day when supply engineers have forgotten the daily peak and are screaming about the winter peak. Then, perhaps, we can begin to think about " winding up the spring " to some purpose.

Yours faithfully,
A. M. GUNNER.

Rugby.
12 February, 1961.

Breakdown on the Motorway?

SIR, Did your 1·2 litre car on the motorway break down? See Fig. 4 of your article " Four Factors Govern Petrol Consumption " (ENGNG., 10 Feb. '61, p. 216).

Yours faithfully,
JOAN D. TARGETT.

Weybridge, Surrey.
13 February, 1961.

Editor's note.—Fig. 4 was a chart showing the use of different gears as a percentage of driving time for various traffic conditions. In the section representing driving on the motorway, the components did not, regrettably, total 100 per cent. The author tells us that the final column in the chart should have represented 88 per cent, not 39.

Food Research Laboratories

SIR, I was interested to read in your Outlook 1961 article on " Agricultural and Food Equipment " (ENGNG., 27 Jan. '61, p. 167) an item of news headed Long Term Research. In the second paragraph under this heading, the Food Investigation Organisation of the Department of Scientific and Industrial Research is mentioned.

You will remember that, in the field of food research, the Department have now only one laboratory—the Torry Research Station at Aberdeen. The other laboratories—the Low Temperature Research Station at Cambridge and the Ditton Laboratory at Maidstone—were handed over to the Agricultural Research Council in July, 1959, together with the Pest Infestation Laboratory at Slough.

Yours sincerely,
NORMAN MANNERS,
Chief Press Officer.

Department of Scientific
and Industrial Research,
London, SW1.
3 February, 1961.

The Engineer's Status

SIR, Did Capricorn in Plain Words (ENGNG., 11 Nov. '60, p. 636) wish to be taken seriously? His selection of a *nom de plume* suggests the very reverse. Capricorn, The Goat, is more noted for his offensive smell than for his capacity to reason. The engineer's concern for his professional standing is a natural and proper attitude, and this reply is intended for those who may have taken Capricorn's attack to heart.

Capricorn says " The earliest references showed the engineer to be an uncouth fellow " who, " by bringing explosives and other devilish engines on to the battlefield, debased the art of war and took the chiv out of chivalry." His further references make it clear that he refers, not to the period of Archimedes, but to the Middle Ages—that period of ignorance between the fall of classical civilisation and the Industrial Revolution. But was the use of the petard in war more uncouth than the use of the flail, thumbscrew and rack in peace? And was the engineer really more uncouth than the knight who patronised and encouraged him?

The engineers who emerged in the second half of the 18th century could not arise from the squires or yeomen who, with the Church, were bitterly opposed to the growth of industrialism. Neither could they develop from the agricultural serfs who had neither the facilities nor the rudimentary education to experiment and propound new ideas. The " new " engineers, of necessity, arose from the craftsmen and tradesmen that preceded them. How else could they

emerge? By biological mutation? Thus, when Capricorn says "As late as 1747 the engineer was classed as a tradesman," he reveals nothing but his lack of professional pride and an ability to isolate a date to suit his ends.

It was the engineer with his new techniques who initiated the Industrial Revolution, from which developed our modern civilisation. All other branches of industry and science have made their great contributions to our present standard of life but all of them have benefited from the work of the engineer. Suffice it to say that from the "uncouth engineer" of the Middle Ages and from the "tradesman of 1747," there arose the pioneers of our modern way of life. If the politician, economist and speculator have, at times, misused, misdirected or arrested the work of the engineer, then the moral responsibility for the social consequence is theirs.

Capricorn suggests that by pressing their claims too fervently professional people sacrifice their dignity. Does the engineer lose "face" when his association negotiates salary increases? Incidentally, "Top entertainers like Sellers and Hancock" may not "make a song and dance about being in show business," but they do engage full-time agents to negotiate their contracts and they are thus relieved of the need for collective representation.

One of the definitions given in my dictionary for the word "status" is relative position in regard to others in attainment, professional reputation and the like. This definition implies a conscientious purposeful effort towards a definable objective. On the other hand, when Capricorn says "Status seeking is the spanner in the works of our society," he clearly means social climbing.

The engineering achievements of the past two centuries have established for the engineer a recognition of his vast contribution to society and his important part in it.

The enormous structures, complicated machines and intricate instruments of the present day are designed on established mechanical and electrical principles that had their simple beginnings only two hundred years ago. Neither Capricorn nor any other sign of the zodiac has any power to impede further progress or detract from the professional status of those who assist it.

Yours faithfully,

A. R. BEDDING.

Gillingham, Kent.
18 February, 1961.

Events in Advance

The Professional Engineer's Contribution

VERY encouraging support is being received by the Engineers' Guild for the one-day conference on "The Professional Engineer—His Employment and Development," which they are organising at the Connaught Rooms, Great Queen Street, London, WC2, on 22 March next.

Among those who have already declared their intention of attending the conference are members of top management, educationists, and personnel officers, as well as the managing directors of a variety of firms, ranging from the quite small to the very large. Professional engineers engaged in many kinds of private industrial enterprises and Government establishments have also made known their desire to take part.

The conference is being arranged to examine the role of professional engineers in Britain and to explore the various avenues by which industry may derive the maximum benefit from their services. Three addresses will be submitted and discussed. That by Mr. D. J. Mann, a director of Unilever Limited, will deal with the extent to which industry requires professional engineers, the types of work they are required to undertake, and the reasons for the proclaimed shortage of their numbers.

Mr. A. R. Cooper, M.Eng., M.I.E.E., member for operations and personnel of the Central Electricity Generating Board, will deal with the question of engineers in management. Among other aspects, he will discuss how far engineers are needed in general management and the extent to which engineers want general management responsibilities. Viscount Chandos, chairman of Associated Electrical Industries Limited, in his address, will consider the distinctive collective contribution being made by the engineering profession to the development of society, as well as the contribution which the profession can make in the future.

The chairman of the conference will be the President of the Guild, Sir Hugh Beaver, K.B.E., M.I.C.E. Application forms, synopses of the addresses and additional information may be obtained from Mr. J. G. Orr, M.A.(Cantab), secretary of the Guild. The offices of the Guild are now at 201 High Holborn, London, WC1, and not as stated in our "Events in 1961" insert accompanying last week's issue.

Modern Jewellery Design—Goldsmiths' Exhibition

AN EXHIBITION of modern jewellery, covering the period from 1890 to the present time, is due to be held during October and November next at the Goldsmiths' Hall, London, EC2. The event will constitute the world's first major international exhibition on these lines and will have as its general theme the evolution of 20th century jewellery design. Its purpose will be to stimulate public interest in jewellery as an art and to provide encouragement to British designers in this field.

Some 20 different countries are lending pieces of jewellery representing significant stylistic trends, so that the items on display are expected to include outstanding examples by such masters of the Art Nouveau period as Lalique, Jensen, Tiffany and Fabergé. The main emphasis of the exhibition, however, will be centred upon jewels of the present day and, among the items to be placed on show, will be examples specially commissioned for the occasion by the Worshipful Company of Goldsmiths, who are organising this venture in association with the Victoria and Albert Museum.

All communications relating to exhibition should be sent to the Clerk, the Worshipful Company of Goldsmiths, Foster Lane, EC2 (telephone: MONarch 1668).

Exhibitions and Conferences

Institution of Mechanical Engineers, Summer Meeting.—Mon., 19 June, to Thurs., 22 June, in Glasgow. Offices of the Institution: 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

Education and Training in the Plastics Industry, Conference.—Mon. and Tues., 19 and 20 June, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Organised by the Plastics Institute, 6 Mandeville Place, London, W1. Tel. WELbeck 5439.

Laboratory Apparatus and Materials Exhibition, Second National.—Mon., 19 June, to Thurs., 22 June, in the Royal Horticultural Society's New Hall, Greycoat Street, London, SW1. Organisers: UTP Exhibitions Ltd., 9 Gough Square, Fleet Street, London, EC4. Tel. FLEet Street 3172.

Heat Transfer, International Conference.—Mon., 19 June, to Sat., 24 June, at 7 Rue la Pérouse, Paris. Organised by the Institut Français des Combustibles et de l'Energie, 3 Rue Henri-Heine, Paris 16e.

Plastics Exhibition and Convention, International (INTERPLAS).—Wed., 21 June, to Sat., 1 July, at Olympia, London, W14. Organised by *British Plastics*, Dorset House, Stamford Street, London, SE1. Tel. WATerloo 3333.

Textile Fair, Third International (MTI).—Fri., 23 June, to Thurs., 29 June, in Paris. Agents in the United Kingdom: Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Fire-Fighting Apparatus and Safety Equipment (INTERSCHUTZ).—Fri., 23 June, to Sun., 2 July, in Cologne. In the United Kingdom, applications should be made to Mr. Neven du Mont, 123 Pall Mall, London, SW1. Tel. WHItehall 8211.

Space Technology, First European Symposium on.—Mon., 26 June, to Wed., 28 June, in London. Organised by the British Interplanetary Society, 12 Bessborough Gardens, London, SW1. Tel. TATe Gallery 9371.

Measurement Conference, International (IMEKO); and International Instrument Show.—From Mon., 26 June, to Sat., 1 July, in Budapest, Hungary. Applications may be made to the IMEKO Secretariat (Assistant Professor György Striker, executive secretary), PO Box 3, Budapest 5, Hungary. In the United Kingdom, applications should be addressed to Professor J. F. Coales, Cambridge University, Trumpington Street, Cambridge.

Large Dams, Seventh International Conference.—Mon., 26 June, to Sun., 9 July, in Rome. Organised by the International Commission on Large Dams of the World Power Conference. Apply to the secretary, British National Committee on Large Dams, 201-202 Grand Buildings, Trafalgar Square, London, WC2. Tel. WHItehall 3966.

Automation: Men and Money, Conference.—Tues., 27 June, to Fri., 30 June, at Harrogate. Organised by the British Conference on Automation and Computation, c/o the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Tel. COVent Garden 1871.

Treatment of High-Level Radioactive Wastes, Symposium.—In July. Apply to the International Atomic Energy Agency, Kaertnerring, Vienna 1, Austria. (*The location of this symposium has not yet been decided.*)

Sports Goods Fair, International.—Sat., 1 July, to Mon., 3 July, at Weisbaden. Organised by the Verband Deutscher Sportgeschafte e.v., 182A Markstrasse, Krefeld-Rheinland.

Royal Agricultural Society's Show.—Tues., 4 July, to Fri., 7 July, in Cambridge. Organised by the Royal Agricultural Society of England, 35 Belgrave Square, London, SW1. Tel. BELgravia 5323.

Ophthalmic Optical Trade Exhibition and Conference.—Tues., 4 July, to Fri., 7 July, at the Royal Albert Hall, London, SW7. Organised by Ophthalmic Exhibitions Ltd., Columbia House, 69 Aldwych, London, WC2. Tel. CHAncery 6146.

Textiles Exhibition, International (INTERSTOFF).—Tues., 4 July, to Sat., 8 July, in Frankfurt. Agents in the United Kingdom: Lep Transport Ltd., Sunlight Wharf, Upper Thames Street, London, EC4. Tel. CENtral 5050.

Radio Techniques and Space Research, Convention.—Wed., 5 July, to Sun., 9 July, at Christ Church, Oxford. Organised by the British Institution of Radio Engineers, 9 Bedford Square, London, WC1. Tel. MUSeum 1901.

Russian Trade Fair.—Fri., 7 July, to Sat., 29 July, at Earls Court, London, SW5. Organised by Industrial and Trade Fairs Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Commercial, Industrial and Agricultural Fair.—Sat., 8 July, to Sun., 23 July, at Elizabethville, Congo. Fair offices: 2180 Avenue Leman (P.O. Box 1916), Elizabethville, Congo.

Housewares Exhibit, National.—Mon., 10 July, to Fri., 14 July, at McCormick Place, Chicago. Organised by the National Housewares Manufacturers' Association, 1130 Merchandise Mart, Chicago 54, Illinois, USA.

Optical Instruments and Techniques, Conference.—Mon., 10 July, to Fri., 14 July, in London. Arranged under the auspices of the International Commission for Optics, by the British National Committee for Physics. Inquiries should be sent to Mr. K. J. Habell, National Physical Laboratory, Teddington, Middlesex.

Great Yorkshire Agricultural Show.—Tues., 11 July, to Thurs., 13 July, at the Showground, Harrogate. Offices: Great Yorkshire Showyard, Hookstone Drive, Harrogate.

Inorganic Polymers, International Symposium on.—Tues., 18 July, to Fri., 21 July, at Nottingham University. Sponsored by the Chemical Society, Burlington House, Piccadilly, London, W1. Tel. REGent 0675.

Sydney International Trade Fair.—Tues., 1 Aug., to Sat., 12 Aug., at the Royal Agricultural Society's showground, Sydney, Australia. British participation is being organised by Industrial and

Trade Fairs Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Pure and Applied Chemistry, 21st International Conference of the International Union of.—Wed., 2 Aug., to Sat., 5 Aug, in Montreal. Apply to the secretary-general of the International Union of Pure and Applied Chemistry, Dr. R. Morf, c/o F. Hoffman-La Roche & Co., Basle 2, Switzerland. (*To be followed by 18th International Congress 6-12 Aug.*)

Pure and Applied Chemistry, 18th International Congress.—Sun., 6 Aug., to Sat., 12 Aug., in Montreal. Apply to the secretary, Central Committee, 18th International Congress of Pure and Applied Chemistry, National Research Council, Ottawa, Canada. (*To be preceded by 21st International Conference, 2-5 Aug.*)

Dublin Horse Show.—Tues., 8 Aug., to Sat., 12 Aug., at Dublin. Organised by the Royal Dublin Society, Ball's Bridge, Dublin.

Cambridge University Physical Chemistry Summer School.—Sat., 12 Aug., to Sat., 19 Aug., at Cambridge University. General topic: "Fast Reactions." Apply to Professor R. G. W. Norrish, Department of Physical Chemistry, The University, Cambridge.

"Model Engineer" Exhibition.—Wed., 16 Aug., to Sat., 26 Aug., at Central Hall, Westminster, London, SW1. Organised by *The Model Engineer* (Percival Marshall and Co., Ltd.), 19-20 Noel Street, London, W1. Tel. GERrard 8811.

Energy, Conference on New Sources of.—Thurs., 17 Aug., to Sun., 27 Aug., in Europe. Sponsored by the United Nations. Apply to the Office of Public Information, United Nations, New York, USA.

Meetings and Papers

British Institution of Radio Engineers

LONDON
"Future of High-Speed Storage Systems": Discussion. Computer Group. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 22 Mar., 5.30 p.m.

BIRMINGHAM
"A Pulse Time Multiplex System for Stereophonic Broadcasting," by G. D. Browne. West Midlands Section. Electrical Engineering Department, The University, Birmingham. Wed., 22 Mar., 6.15 p.m.

FARNBOROUGH
"Design of a Long-Range Single Sideband Airborne Equipment," by P. D. Adams and T. E. Wynne. Southern Section. Farnborough Technical College, Farnborough. Wed., 22 Mar., 7 p.m.

MALVERN
"Magnetic Film Storage," by Dr. A. C. Moore. South Midlands Section. Winter Gardens, Malvern. Thurs., 23 Mar., 7 p.m.

British Interplanetary Society

DERBY
"Some Speculations on Extra-Terrestial Life," by S. S. Kind. Seven Stars Inn, 97 King Street, Derby. Mon., 20 Mar., 7.30 p.m.

Chemical Society

BRISTOL
"Frozen Foods": Discussion. Joint meeting with the Royal Institute of Chemistry and the Society of Chemical Industry. Bristol Branch. College of Science and Technology, Ashley Down, Bristol. Thurs., 23 Mar., 6.30 p.m.

MANCHESTER
"Organic Intermediates in the 1960's": symposium. Joint meeting with the Society of Chemical Industry, the Royal Institute of Chemistry and the Institute of Petroleum. Manchester Branch. Chemistry Department, The University, Manchester. Fri., 24 Mar., 10.30 a.m.

Illuminating Engineering Society

LEEDS
"Presenting the Revised Code of Practice for Lighting in Buildings," by H. Hewitt. Leeds Centre. British Lighting Council, 24 Aire Street, Leeds 1. Mon., 20 Mar., 6.15 p.m.

LIVERPOOL
"Characteristics and Applications of Photo-Cells," by F. A. Benson. Liverpool Centre. Electrical Industrial Development Centre, Merseyside and North Wales Electricity Board, Paradise Street, Liverpool 1. Tues., 21 Mar., 6 p.m.

Institute of Marine Engineers

LONDON
Annual General Meeting. Education Group. Tues., 21 Mar., 5.30 p.m.
"Marine Nuclear Power Developments in the United Kingdom over the Period 1957-1960," by E. Norton. Thurs., 23 Mar., 5.30 p.m.

BOLTON
"Metallurgy in Marine Engineering," by Dr. J. E. Garside. Merseyside and North Western Section. Bolton Technical College, Bolton. Thurs., 23 Mar., 3.15 p.m.

KINGSTON UPON HULL
"Details and Operating Data of Recent Alternating-Current Installations in Ships," by A. N. Savage. Kingston upon Hull and Humber Section. Royal Station Hotel, Kingston upon Hull. Thurs., 23 Mar., 7.30 p.m.

Institute of Metals

SWANSEA
Annual General Meeting and Chairman's Address. South Wales Local Section. Metallurgy Department, University College, Singleton Park, Swansea. Tues., 21 Mar., 6.30 p.m.

Institute of Road Transport Engineers

DURHAM
"Future of Road Transport," by A. Enticknap. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., 21 Mar., 7 p.m.

GLASGOW
"Future of Road Transport," by A. Enticknap. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. Mon., 20 Mar., 7.30 p.m.

Institution of Chemical Engineers

LONDON
"Some Factors in the Safe Operation of Air Separation Plants," by J. B. Gardner. Geological Society, Piccadilly, W1. Tues., 21 Mar., 5.30 p.m.

Institution of Civil Engineers and the Société des Ingénieurs Civils de France (British Section)

LONDON
"The Work of the Channel Tunnel Study Group," by J. M. Bruckshaw, J. Goguel, H. J. B. Harding and R. Malcor. At Institution of Civil Engineers, Great George Street, SW1. Tues., 21 Mar., 5.30 p.m.*

Institution of Civil Engineers

LONDON
"Traffic Engineering Problems on Motorways Between Cities and Airports in France": Discussion, introduced by H. Grimond. Traffic Engineering Study Group. Thurs., 23 Mar., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Self-Adaptive Control Systems": Discussion, opened by Dr. J. H. Westcott, Dr. J. L. Douce, Dr. P. E. W. Grinsted and P. H. Hammond. Measurement and Control Section. Tues., 21 Mar., 5.30 p.m.*
"Engineering Aspects of Plasma Physics," by R. Carruthers and D. L. Smart. Joint meeting of the Electronics and Supply Sections. Wed., 22 Mar., 5.30 p.m.*

BIRMINGHAM
"The Integration of Industrial and Academic Training": Discussion, to be introduced by E. C. Merrick. South Midland Education Discussion Circle. College of Technology, Gosta Green, Birmingham. Thurs., 23 Mar., 6 p.m.

EDINBURGH
"The Potentialities of Artificial Earth Satellites for Radio communication," by W. J. Bray. South East Scotland Subcentre. Carlton Hotel, Edinburgh. Tues., 28 Mar., 7 p.m.

GLASGOW
"A General Theory of Depreciation of Engineering Plant," by D. Rudd. South West Scotland Subcentre. Institution of Engineers and Schipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. Wed., 22 Mar., 6 p.m.

HULL
"Transmission of News Film Over the Transatlantic Cable," by C. B. B. Wood and I. J. Shelley. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Tues., 21 Mar., 6.30 p.m.

MALVERN
"Radio Communications by Means of Satellites," by Dr. A. W. Lines. South Midland Centre. Winter Gardens, Great Malvern. Mon., 20 Mar., 7.30 p.m.

MANCHESTER
"Experimental Methods with Particular Reference to Transistors:" Discussion, to be opened by V. H. Atree. North Western Education Discussion Circle. Manchester College of Science and Technology, Manchester. Mon., 20 Mar., 6.15 p.m.

NEWCASTLE UPON TYNE
"Transistors and All That," by L. J. Davies. Faraday Lecture. North Eastern Centre. City Hall, Newcastle upon Tyne. Thurs., 23 Mar., 7 p.m.*

WEYMOUTH
"High-Voltage Engineering," by E. L. White. Southern Centre. South Dorset Technical College, Weymouth. Thurs., 23 Mar., 6.30 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
"Recent Developments in Firing and Handling of Solid Fuels in Domestic and Industrial Boiler Plants," by R. Cleland. Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C2. Tues., 28 Mar., 7 p.m.

Institution of Locomotive Engineers

LONDON
"Cooling Equipment for Diesel Locomotives," by T. Rudge and M. Forbes. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Tues., 21 Mar., 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
"The Application of Mechanical and Biological Knowledge in Engineering," by Sir Frederic Bartlett. James Clayton Lecture. Wed., 22 Mar., 6 p.m.*
"Running-in Practice for Internal-Combustion Engines": Discussion. Lubrication Group. Mon., 20 Mar., 6 p.m.*

BELFAST
"Some Problems We Meet": Presidential Address by L. H. Dawtrey. Northern Ireland Branch. Central Hall, Technical College, Belfast. Tues., 21 Mar., 6.45 p.m.

BRISTOL
"Blade Profiles for Axial-Flow Fans, Pumps, Compressors, etc.," by Professor A. D. S. Carter. Ordinary Meeting. Engineering Laboratory Lecture Theatre, The University, Bristol. Tues., 21 Mar., 7 p.m.

MANCHESTER
"Development of Some Unconventional Pumps," by Dr. U. M. Barske. Annual General Meeting. North Western Branch. College of Science and Technology, Sackville Street, Manchester. Thurs., 23 Mar., 6.45 p.m.

SOUTHAMPTON
Annual General Meeting and Chairman's Address. Southern Branch. Polygon Hotel, Southampton. Thurs., 23 Mar., 7.30 p.m.

Institution of Plant Engineers

BRISTOL
"Closed-Circuit Television," by I. M. Waters. Annual General Meeting. Western Branch. Grand Hotel, Broad Street, Bristol. Wed., 22 Mar., 6.15 p.m.

LEEDS
Annual General Meeting. West and East Yorkshire Branch. Houldsworth School of Applied Science, The University, Leeds. Mon., 20 Mar., 7.30 p.m.

LEICESTER
Annual General Meeting. Leicester Branch. Midland Hotel, Leicester. Wed., 22 Mar., 7.30 p.m.

Institution of Production Engineers

LEEDS
"Work Study," by G. A. Daniell. Annual General Meeting. Leeds Section. Hotel Metropole, King Street, Leeds 1. Mon., 20 Mar., 7.0 p.m.

MANCHESTER
"Furniture Making Today and Tomorrow," by A. J. Robins. Manchester Graduate Section. College of Science and Technology, Manchester. Wed., 22 Mar., 7.15 p.m.

NEWCASTLE-UNDER-LYNE
"Management, Selection and Training," by F. W. Tymdale. Joint lecture with the Institute of Personnel Management. Stoke-on-Trent Section. Pitfield House, Newcastle-under-Lyne. Tues., 21 Mar., 6.30 p.m.*

WORCESTER
Annual General Meeting and Film Evening. Worcester Section. Star Hotel, Worcester. Wed., 22 Mar., 7 p.m.

Institution of Structural Engineers

LONDON
"Rubber-Tyred Overhead Cranes: Their Influence on the Design of Industrial Buildings," by E. M. Lewis. Thurs., 23 Mar., 6 p.m.*

BIRMINGHAM
"Models for Design and Research in Reinforced Concrete," by Geoffrey Brock. Midland Counties Branch. College of Advanced Technology, Gosta Green, Birmingham 6. Fri., 24 Mar., 6.30 p.m.

GLASGOW
"Design and Construction of the Pannier Market at Plymouth," by A. P. Mason. Scottish Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. Tues., 21 Mar., 7 p.m.

SCUNTHORPE
"Civil Engineering Problems in Nuclear Power Station Construction," by A. L. Brake. Yorkshire Branch. Joint meeting with the East Midlands Association of the Institution of Civil Engineers. Blue Bell Hotel, Scunthorpe. Tues., 21 Mar., 6.15 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Fuel Cells," by Dr. H. H. Chambers. Neville Hall, Westgate Road, Newcastle upon Tyne. Fri., 24 Mar., 6.15 p.m.

Royal Aeronautical Society

LONDON
"Some Aspects of Buffeting," by R. Fail. Tues., 21 Mar., 7 p.m.
"Problems of Short Take-off and Landing," by H. Ziegler. Louis Bleriot Memorial Lecture. Thurs., 23 Mar., 6 p.m.*

Royal Society of Arts

LONDON
"Economic and Commercial Aspects of the Steel Industry," by Sir Robert Shone. Wed., 22 Mar., 6 p.m.

Royal United Service Institution

LONDON
"Comments on the Nuclear Controversy," by Professor P. M. S. Blackett. Wed., 22 Mar., 3 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Technologists as Successful Managers," by R. Coverdale. BISRA Laboratories, Hoyle Street, Sheffield. Mon., 20 Mar., 7 p.m.

Society of Instrument Technology

CHELTENHAM
"The Measurement of Vibration": Discussion. Cheltenham Section. Belle Vue Hotel, Cheltenham. Fri., 24 Mar., 7.30 p.m.

WIRRAL
"Electromagnetic Flowmeters," by Leo M. Bennett. Chester Section. Administration Building, Associated Ethyl Co., Ltd., Oil Sites Road, Ellesmere Port, Wirral. Thurs., 23 Mar., 7 p.m.

Television Society

LONDON
"Underwater Television in Marine Biology," by Dr. H. Barnes. Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, WC2. Thurs., 23 Mar., 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Heat Treatment," papers by F. Darroch, D. M. Clinton and D. M. Syme. Fri., 24 Mar., 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901)
British Interplanetary Society, 12 Bessborough Gardens, London, SW1. (TATe Gallery 9371)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Marine Engineers, Memorial Building, 87 Mark Lane, London, EC3. (ROYal 8493)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291)
Institute of Road Transport Engineers, 69 Victoria Street, London, SW1. (ABBey 6248)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Locomotive Engineers, 28 Victoria Street, London, SW1. (ABBey 6672)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515)
Royal Society of Arts, John Adam Street, Adelphi, London, WC2. (TRAfalgar 2366)
Royal United Service Institution, Whitehall, London, SW1. (WHItehall 5854)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865)
Société des Ingénieurs Civils de France (British Section), 82 Victoria Street, London, SW1. (VICtoria 6838)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)
Television Society, 166 Shaftesbury Avenue, London, WC2. (TEMple Bar 3330)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C2. (Central 5181)

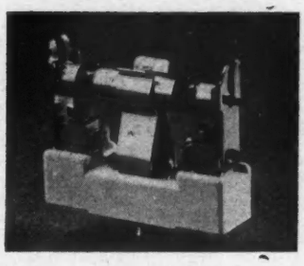
LINE PROTECTOR

Ceramic and Metal

A GAS FILLED line protector using only ceramic and metal parts has been developed.

The unit, type 16, is the three electrode design and is smaller in size than earlier types. It is claimed that it can replace two or three two electrode protectors. A new feature for gas filled designs is that the arrangement of the electrodes tends to short circuit a severely overloaded gap thus maintaining safe conditions on the line. The use of high temperature brazed ceramic-to-metal seals allows the envelope to run at high temperatures, increasing the current handling capacity for the size. The new unit is $1\frac{15}{16}$ in long and $\frac{3}{4}$ in diameter.

The protector is available in three overlapping ranges of striking voltage covering from 150 to 900 V dc. A coating of heat resistant enamel between the electrodes gives added protection against dust and moisture deposits, and is also coloured to indicate the striking voltage range. Operating delay is less than 1 microsecond when 1,500 V dc



with a rise time of less than 0·1 microsecond is applied. The protector will withstand without damage ten one-second applications of 20 A ac every three minutes on any one section. It will also withstand at least 150 mA ac for three hours without damage. Insulation resistance measured at 85 V is greater than 1,000 megohms between any two electrodes and high insulation is maintained under high humidity conditions. Arc voltage is of the order of 20 V, so heavy current surges can be handled. Up to 100 Joule discharges where peak current is greater than 10,000 A can be taken on any gap. *AEI Telecommunications Division, Woolwich, London, SE18.*

TIMER

Automatic Self-Resetting

VISUAL indication of time progress is given on the Star model synchronous timers.

Both expired and unexpired times are shown on the dial. The preset time is obtained by rotating the bezel—there are no knobs to operate.

A solenoid-operated clutch is used to couple the drive from a miniature synchronous motor to the cam and pointer. The timer resets when the clutch is de-energised. There are 15 models with maximum time scales from 12 seconds to 24 hours. Operation is within 1/10 second from push button impulse or switching on the supply, as appropriate, and the pointer travels towards the set time from zero. The set time is continuously indicated and the pointer takes less than half a second to reset from any position. High setting resolution and repetition are claimed.

There are standard models to operate on 110V, 200-240V and 400-440V supplies, the switching capacity being 5A at 240V ac or ½A at 440V ac.

Model Star has changeover action for the preset time (during the timing period), the output being from the timer supply, and model Star/D has changeover after the preset time.

All the terminals are mounted in a barrier protected moulding on the back of the timer. Overall dimensions are $5\frac{3}{4}$ in long (including $1\frac{1}{16}$ in front projection) by $4\frac{3}{8}$ in diameter of body. *Electrical Remote Control Company Limited, Bush Fair, Harlow, Essex.*

CONTACTOR

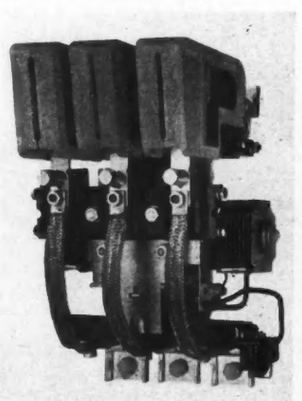
Multi-Unit Heavy Duty Type

UNIT contactors are now available either as single or multi contact sets to which additional poles can be added.

The H series is made in three ratings of 50, 100, and 200A for both ac and dc working. The addition of an extra pole does not necessitate the changing of the operating coil. It is claimed that the unit mounting and front wiring of the contactors facilitates installation and maintenance as does the single screw fixing of the contacts and coil. All units are said to be exceptionally quiet in operation making them suitable for use where silence is an advantage. They are rated to BS 775 (A4 or D4) and have full CSA approval. Short circuit tests have been carried out on them at 21MVA against their respective HRC ratings.

The blow-out system, said to be unique, incorporates separate tungsten arcing contacts to obviate derating and to ensure long life.

Extras that are available for the contactors include auxiliary contact assemblie



and damp and dust protecting, or weather proof cases. They are intended for use in any climatic conditions and are quoted as competitively priced. The illustration shows a three pole assembly with arc shields in place. *Dewhurst and Partner Limited, Inverness Works, Hounslow, Middlesex.*

CONVERTOR

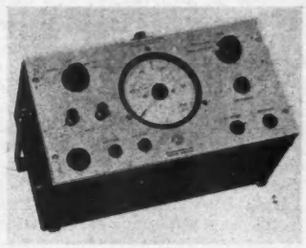
Range from 10 to 5,000 Cycles

A FREQUENCY converter with a linearity of 0·75 per cent using an internal meter has been announced.

The instrument is intended for use as a tachometer or a rate meter for speed measurements when operating with suitable transducers able to generate electrical impulses. It can also be used with the firm's impeller flowmeters to give the rate of flow of a liquid. Using a precision indicator the linearity can be increased to 0·25 per cent.

The circuit is completely transistorised and indication is on an open-scale $3\frac{1}{2}$ in meter with provision for the external indicator, chart or galvanometer recorder. The standard instrument, type SE 700, gives a choice of three frequency ranges up to 200 cycles, 1,000 cycles and 5,000 cycles respectively. The instrument can be calibrated before use and operates from internal batteries or mains as desired, stabilised against ± 15 per cent mains variation. Temperature operating range is from − 20° C to + 45° C.

Input signal range is from 10 mV to



10 V rms and input impedance is 15,000 ohms. Output available is 1 mA into 100 ohms or 100 mV into loads greater than 400 ohms. Power is supplied by 9 volt battery, or 200-250 volt 40 to 60 cycles mains. The battery capacity is for 500 hours continuous use. An easily accessible compartment at the back houses the battery and the connecting leads. Input connections are two spring loaded terminals and output are two Igranic sockets. The case measures $10\frac{1}{2}$ in by $5\frac{3}{8}$ in by 6 in including the snap-on lid. The weight is approximately 9 lb. *Meterflow Limited, North Feltham Trading Estate, Feltham, Middlesex.*

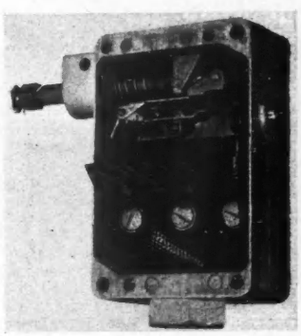
PULSE SWITCH

Mechanically Operated

A NEW switch provides a means of obtaining an electrical pulse of predetermined length.

Known as the 1PD1 the switch is designed for industrial applications in which momentary opening and closing of a circuit is necessary. For example it is useful when controlling pneumatic valves where permanent duty solenoids are not used. The 1PD1 minimises electrical component failure caused by prolonged energising of the circuit.

The entire pulse operation—a single pulse consisting of actuation and release—is accomplished by depressing the operating plunger which closes the contacts during a definite length of travel of the operating rod. The pulse length is directly dependent on the speed of external plunger motion; a simple adjustment can change the pulse length from 0·03 in to 0·45 in, beyond which the unit becomes a standard limit switch. The unit has a life rating of 5 million operations and is sealed against dust and oil. The electrical rating of the



single pole double throw contacts is 10 A at up to 480V ac or ¼A at 125V dc and ¼A at 250V dc.

Connections are made by sealed conduit to maintain the oil and dust proofing so that the switch can be used in many plant applications that require pulses for marking, starting timing circuits, and for initiating sequence operations even when working under dirty conditions. *Honeywell Controls Limited, Greenford, Middlesex.*

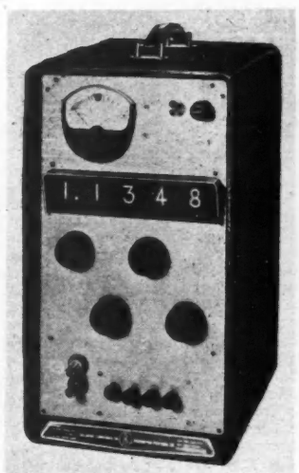
VOLTMETER

For Complex Wave Forms

RECENTLY announced by the Ballantine Laboratories is a new voltmeter model 350 that will give true rms values of complex wave forms.

The instrument provides a five digit Nixie readout prominently displayed. The voltage range is from 0·1 volt to 1,199·9 volts. The acceptable frequency range of the signal is from 50 cycles to 20 kc/s with a harmonic content to 50 kc/s. Measurements with this new model are not limited to sinewaves, although these can be measured to ¼ per cent accuracy. Wave forms from sinewaves to square waves can be measured so long as the ratio of peak to rms value is not greater than 2. This means for example that a sinewave with 50 per cent harmonic distortion can be accurately measured. The ¼ per cent accuracy is reduced to ½ per cent for voltages above 300, and for frequencies below 100 c/s or above 10 kc/s.

The instrument is housed in a metal case with the controls on the front panel. A fuse and a main switch are included.



The input has an impedance of 2 megohms and 20 pF. *Sylvan Ginsbury Limited, 8 West 40th Street, New York, NY, USA.*

Electrical Engineers Exhibition

Earls Court, London, 21-25 March

COMMUNICATIONS is the theme of the Tenth Electrical Engineers exhibition due to be opened on 21 March by the Rt. Hon. Frederick Erroll, M.A., M.I.E.E., A.M.I.Mech.E., Minister of State, Board of Trade—not communications in the sense usually attributed to the word by electrical engineers, but in the wider sense that includes transport, powered though by electricity.

The British Transport Commission are showing aspects of railway modernisation with both models and working equipment, including a set of actual signal cabin controls. The General Post Office are planning a working demonstration of how signals are received from a satellite using echoes at 960 Mc. More earthly are examples of Telex services and subscriber trunk dialling.

"Newhampton" is a town developed by the Central Electricity Generating Board, which is truly all-electric and includes a power station, electric underground railway and electrified main line. A dial shows how the electricity demand varies throughout the 24 hours. Among exhibits by firms are a section of the cross-Channel cable, instruments and domestic equipment with, over the entrance, what is claimed to be the world's largest moving coil ammeter—17 ft square with a scale 20 ft long—that will register the total electrical load, which is expected to reach 4 MW, during the exhibition.

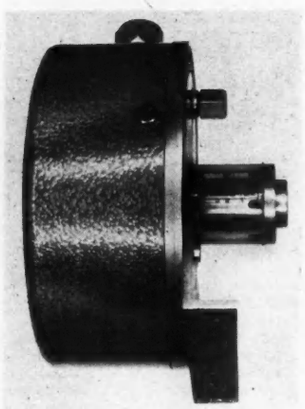
PRESSURE SWITCH

High Sensitivity Action

HIGH sensitivity is one of the features of the pressure switch illustrated, the model PS/A.

The switch is suitable for operating on extremely low pressures and has fitted to it a scale plate and pointer indicating the pressure setting. Although of high sensitivity it incorporates directly operated snap action contacts. The maximum pressure permissible is 30 in of water gauge and typical adjustable ranges are from 0·5 to 3·5 in water gauge. The reset differential of the standard model is approximately 0·4 in water gauge.

The switch is housed in a machined brass casing for the diaphragm, with a spun metal cover. The pressure sensitive element is a diaphragm of nylon reinforced Neoprene. For connecting up to the pressure vessel the unit is normally fitted with a $\frac{1}{8}$ in BSP male end complete with a compression coupling of the Simplifix type for accepting $\frac{5}{16}$ in outside diameter tube. The dimensions are 6 in over the cable entry by $2\frac{1}{4}$ in deep.



The scale plate projects a further $1\frac{1}{2}$ in and the bracket has fixing holes $\frac{9}{32}$ in diameter at $\frac{7}{16}$ in from the case. The snap action changeover contacts are suitable for 2A at 440 V ac and are completely isolated from the pressure medium. *Londex Limited, Anerley Works, 27 Anerley Road, London, SE20.*

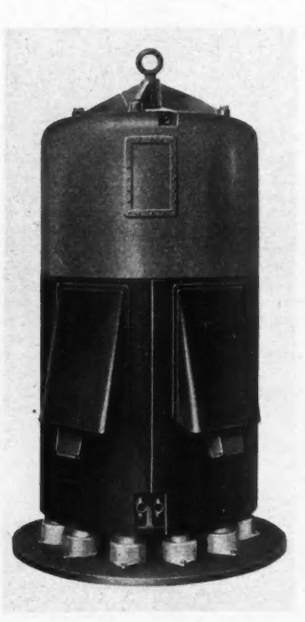
MOTOR GENERATOR

Vertical Spindle

THE VERTICAL spindle motor generator set illustrated is designed primarily for induction heating plant.

The sets can be supplied to operate at frequencies up to 10,000 cycles and with fast response times where quick changes of load demand rapid control of output voltage. Each set consists of a squirrel cage motor and an ac generator having the two rotors mounted on the same vertical shaft. Cooling is effected by a closed air circuit incorporating a water cooled heat exchanger. The construction ensures quiet running besides saving on floor space. The sets are resiliently mounted.

The low tension driving motor is designed for high starting torque and runs from a 50 or 60 cycles system. The generator output is from 600 to 1,200V, typical outputs being 250 kW at 10,000 cycles running at 3,600 rpm (illustrated), and 300 kW at 1,000 cycles running at 3,000 rpm. *Electric Construction Company Limited, Bushbury Engineering Works, Wolverhampton.*



HEATING CONTROL CONTACTORS

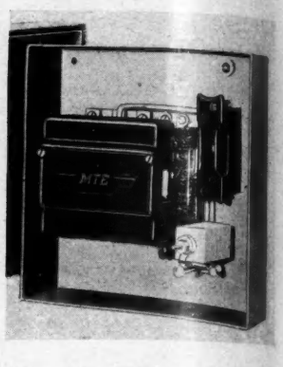
Packaged Units

SPECIALLY developed for the control of heating systems is a new series of "Progress" contactors.

These are available as open or enclosed types and are unit constructed. They are being made in single, double or triple pole form. There is a choice of several materials for the contacts which are of double break design. They can be made in fine silver, silver tungsten, or silver cadium oxide. Six models have contact ratings covering currents ranging from 15 to 150 A.

The fixed contacts and the posts are mounted in shock resistant mouldings and all the contacts are protected by an arc barrier and cover made of an alkyd moulding. The standard complement includes one normally open auxiliary contact. Control circuits for the standard models are arranged for operation on a line and neutral supply.

It is particularly claimed for the contactors that they are compact in size, suitable for heavy duty operation, and silent in action. They comply fully with



BS 775: 1956. Front access and front wiring make for easy installation and maintenance, and the sheet steel enclosures are dust and damp proof. The enclosures incorporate knock-out conduit entries at both top and bottom so that the wiring can be made to suit position. There are several extras available, including neutral links, control circuit fuses (rewirable or hrc type) and weatherproof enclosures. *M.T.E. Control Gear Limited, Leigh-on-Sea, Essex.*

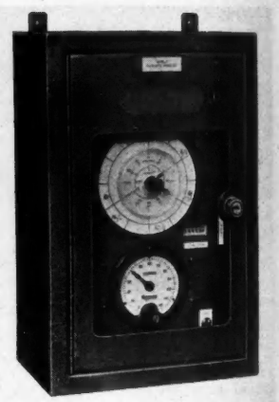
BONUS CLOCK

Multi-Circuit Operation Timer

THE bonus clock is designed to show an operator continuously whether time is being gained or lost on each work item.

The clock is started by the operator at the beginning of each job either by a push button or alternatively by a switch on the machine or by the passing of the new item down the feed chute. The time for the job is set on the dial and when the cycle is initiated the clock begins to record, showing a green light. If the completion of an item as indicated by the finishing switch is delayed, then lost time is recorded and a red lamp lights; if on the other hand the item is finished before the set time then time gained is marked up, the clock showing an automatic running total of gains and losses. At the same time the total number of items handled is recorded.

The timing circuits of the clock are arranged so that too rapid pushing of the finish button is inoperative and if the button is pushed a little too soon each time there is no cumulative gain. The



attempt would also be obvious as the "gaining bonus" indicator light would come on at the wrong time. Experience has shown that operators using the clock have been able to improve output by as much as 22 per cent without strain. *D. Robinson and Company Limited, 5-7 Church Road, Richmond, Surrey.*

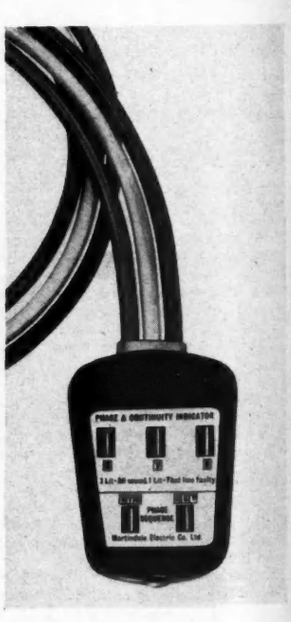
PHASE AND CONTINUITY TESTER

Combined Instrument

PHASE sequence and continuity can be checked by a single instrument shortly to be on the market.

The instrument is contained in a moulded plastics case small enough to hold in one hand. Under a non-breakable transparent cover are five neon tubes arranged in two rows, the top three indicating continuity and the lower two the direction of phasing. There are no moving parts and the instrument is fused. There are also current limiting resistors in the probes of each lead.

Contact is made by crocodile clips at the end of heavily insulated leads. The clips are shrouded with rubber leaving an operating lever projecting. If all the top lamps and one of the bottom lamps light, when the probe clips are connected, there is continuity in all phases. If only one lights that line is faulty. The present model is suitable for 380 to 440 volts, 50 to 60 cycles. *Martindale Electric Company Limited, Westmorland Road, London, NW9.*



Human Element

Operating Electrical Plant in Hazardous Areas

FROM the introduction of electrical prime movers and signalling methods into industry, the problems of using electrical plant in potentially dangerous areas has engaged the continuous attention of engineers in coal mining, the chemical industry and in explosives.

Mr. W. J. F. Cocks, in his recent paper *Operation of Electrical Plant in Hazardous Areas*, read to a meeting of the Association of Supervising Electrical Engineers, defined a hazardous area as one in which any flammable substance, whether gas, vapour or volatile liquid is processed, handled or stored and where during normal operations an explosive or ignitable concentration is likely to occur in sufficient quantity to produce a hazard.

Dealing in this paper with the electrical equipment at petroleum depots, Mr. Cocks recalled that when the electric motor was first introduced to the depot it was frequently of a totally enclosed type. The motor, with its switchgear, was separated from the pump by a barrier wall through which the driving shaft ran through sealing glands. This method is still used where there are especially flammable gases.

The modern depot has storage for up to 5,000 tons of petroleum, while larger installations may have storage for up to 275,000 tons and handle annually some 1,000,000 tons. Electrical demand for a depot will be between 200 and 500 kVA, and for a larger installation between 500 and 1,000 kVA.

The depot substation will be located in a safe area and it often incorporates a high voltage substation. Main depot switchgear is of medium voltage type, including oil circuit breakers for supply to pump platforms. Circuit breakers are fitted with earth leakage relays and are suitable for emergency remote tripping from pump platforms.

Codes of Practice

A number of regulations govern the operation of electrical plant in a petroleum installation. In addition, the Institute of Petroleum issues a comprehensive *Model Code of Safe Practice in the Petroleum Industry*. There is also the British Standard Code of Practice CP 1003 *Installation and Maintenance of Flameproof and Intrinsically-Safe Electrical Equipment for Industries other than Coal Mining*.

Summarising the prospects for future developments, Mr. Cocks notes that the continued use of flameproof equipment in the open is considered necessary and that many authorities and companies are taking action to ensure that electrical apparatus used in hazardous areas will have suitable flame and weatherproof enclosures.

Due to the ease with which intrinsically safe equipment may be applied to instrumentation and electronic apparatus in hazardous areas, such equipment will be increasingly used for the fully automatic control of process plant in the oil and chemical industries.

Interesting and challenging problems in the design and operation of electrical plant for use in the hazardous areas of petroleum installations are forecast by Mr. Cocks, who observes that the progress made by designers and manufacturers in recent years demonstrates their ability to cope with the high standards of safety needed while keeping up with the demand for equipment.

Refit for the Bells of St. Pauls

Shakespeare's Othello obviously did not share the enthusiasm of the campanologist or the pleasure of the casual listener when he said "Silence that dreadful bell! it frights the isle from her propriety."

For a little while, the precincts of St. Paul's Cathedral will not reverberate to the sound of bells, not as the result of any curse of Othello but because five of the twelve bells which make up the full peal are being re-hung. Installed and dedicated in 1878, the bearings were of the old gunmetal type and during the last 40 years several of them have been re-hung with ball bearings. It is now the turn of the remainder.

To allow this work to be carried out, the bells were temporarily supported on timber baulks to enable the headstocks to be removed. They were then lowered 130 ft to the ground and taken to the bell foundry of John Taylor and Company at Loughborough. During the period that the headstocks are away, repairs will be carried out on the rope wheels and pulleys. It is expected that the full peal will be out of action for three weekends.

Divided Approach to Shipyard Talks

Disagreements within the unions in the shipbuilding industry bedevil the situation not only in the yards but at the top councils of the Confederation of Shipbuilding and Engineering Unions.

When the CSEU meets the employers next week it will be with the knowledge that at least two strongly held and divergent views exist within its own delegation. Mr. Jim Matthews, the president of the CSEU, believes that there are things radically wrong with the industry and that it is equally in the interests of the employers and of the men to put things right and equal the competitiveness of overseas yards. In Mr. Matthews' sights, the target for the meeting on Wednesday (1 March) is a general statement only, confined to the points which the employers wish to discuss. After that, there would follow a series of meetings with some definite action as the result.

The principal exponent of the other view is Mr. Ted Hill, general secretary of the Boilermakers' Society. Mr. Hill says that those British yards which have completed their modernisation schemes are competitive with any in the world. He believes that in time it will be seen that the industry is over its teething troubles.

While Mr. Matthews believes that the Confederation has some power to act on its own (its leaders are senior union executives in their own right) Mr. Hill does not concede that the CSEU can handle matters affecting the affiliated unions' sovereign rights, and there are 39 unions, which limits the field Mr. Hill feels able to allow. In practice this leaves in things like overtime and night work but puts out of bounds many of the detailed practices which the employers wish to deal with in the effort to raise productivity.

At yard level, while next Wednesday's meeting was still a week or so off, a valiant effort by the Boilermakers' Society to cooperate with the Smiths Dock company, of South Shields, in reducing costs was found to have failed, because other unions would not co-operate.

With 80 per cent of the men on the job members of their union, the Boilermakers' Society agreed to forego the 9*d* an hour "dirty money" for working on oil tankers. This sacrifice—amounting to 31*s* 6*d* a week—was to help the company reduce its tender for the conversion of oil tankers into cargo vessels. The cost of each job was cut by £10,000 and Smiths Dock have been able to complete one conversion and start work on another.

But the other men in the yard declined to forego the "dirty money" and the boilermakers have decided that in that case they can no longer give up the traditional special payment. The effect of the extra cost may now be to make the company's tenders uncompetitive.

Vacation Course on Metal Fractures

A postgraduate lecture course in the Metallurgy Department of Battersea College of Technology on the fracture of metals is to be conducted from 11 to 14 April.

The subjects to be covered include practical problems of metal fracture in service, mechanical testing methods for the assessment of fracture behaviour, theoretical aspects of fracture, ductile to brittle transition in ferrous and non-ferrous metals, irradiation effects on fracture behaviour, temper brittleness in steels, hydrogen embrittlement in metals, fracture under creep conditions, fracture under fatigue conditions.

Graduate Opportunities with Pressed Steel

Unusual is the word the Pressed Steel company stresses in describing the career opportunities for graduates who join their organisation. And unusually comprehensive and factual is a reasonable description of the booklet PS have put out, with gay cover and down-to-earth narrative, to outline what the graduate considering joining can expect.

Pressed Steel graduate training is based on a two year programme. The classroom approach is avoided. Instead, individuals are attached to production, manufacturing, administrative and service departments. Programmes are planned with the requirements of the professional institutions in mind. Initial training is at the new group training headquarters at Cowley, Oxford. On each assignment the trainee writes his own report, which is analysed with him by a company executive. At 25 the graduate is able to apply for competitive entry to the executive development course, a two year full-time course designed to fit picked senior men for senior management positions. Graduates qualifying for this course are probably admitted direct to the second year.

December Employment above 1959 Figures

Despite the seasonal fall in the number employed during December (this year it was 164,000) the total number in work at the end of the month was some 400,000 higher last December, than at the end of 1959.

The two totals were 23,711,000 at the close of 1960 against 23,316,000 a year earlier.

The heaviest reduction was in the manufacturing industries (56,000) where 18,000 fewer were employed in the food, drink and tobacco trades. There were 6,000 less in the Ministry of Labour's Engineering and Electrical Goods classification. Of all the divisions made by the Ministry in the manufacturing industries section, only one—Shipbuilding and Marine Engineering—rose, by 2,000 men. Total employment at the year's end in shipbuilding and marine engineering, 250,000, was still 14,000 short of the 264,000 at work at the end of 1959.

Other falls in employment were:

Distributive trades	46,000
Agriculture and fishing	25,000
Construction	18,000

The only gain in the sectors outside manufacturing industries was in Gas, Electricity and Water, where the labour force rose from 376,000 to 377,000.

Introduction to Industry by Westinghouse Brake

The Westinghouse Brake and Signal company are to hold another of their "Introduction to Industry" courses at their Chippenham, Wiltshire, works. Held in the Easter vacation (10 to 14 April) the course will be for sixth form boys who are taking the GCE "A" level examinations in science subjects. The intention of the course is to give the boys a first hand acquaintance with something of the engineering industry and to inform them of the available training facilities and career prospects.

Specimen Syllabus for Graduate Trainees

Engineers	Non-Engineers
Basic Training 36 weeks studying practical operator problems. Pattern making, Fitting, Machine Shop, Sheet Metal Work, Welding.	*Production Departments* 40 weeks to study management and production problems. Tool Manufacture, Welding Department, Press Shops, Assembly Departments, Production Control, Ratesetting.
Production Department 37 weeks studying management and production problems. Tool Manufacture, Welding Department, Press Shops, Assembly Departments, Production Control, Rate setting.	*Engineering* 17 weeks. Elementary Drawing, Experiment, Product Design, Planning, Tool Design.
Engineering 18 weeks. Engineering Drawing, Experiment, Product Design, Tool Design.	*Commercial and Administrative* 18 weeks. Accounts, Purchase, Personnel.
Commercial and Administrative 13 weeks. Technical Sales, Accounts, Purchase Department, Personnel.	Attachment to Department for which finally selected: 29 weeks.

The Latest Practice in Generator Design

Mechanical and transport problems are the main limitations in designing single-unit generators large enough to match high-output modern turbines (see page 294).

By F. R. L. Creek., B.Sc.(Tech), A.M.I.E.E.

AEI Turbine-Generator Division

TO MATCH the increasing output of modern turbines with high steam conditions and high efficiencies, single-unit generators of very large output are required. Whereas 60 MW was the standard generator rating in the immediate post-war years, machines of 375 MW are now under construction, and outputs of 500 MW on a single shaft are already being called for as a result of these advances.

The maximum physical size of a turbogenerator is limited in part by the mechanical design of the rotating field and in part by transport problems associated with the large two-pole stators which are not readily split into sections as is normally possible with the slower speed machines.

ROTOR COOLING

The output obtainable from a turbogenerator is largely determined by the excitation performance of the rotating field. High centrifugal stresses limit both the maximum diameter and the cross-section of copper which can be accommodated in the field winding, and the overall length is restricted by problems associated with critical speeds and balancing. Hence to obtain adequate excitation capability it is essential to have a very efficient method of heat dissipation as the losses in the restricted volume of copper increase rapidly at higher outputs.

Machines of the immediate post-war era were cooled by hydrogen passing through ducts in the rotor body and over the outside of the rotor surface. Early hydrogen-cooled machines operated with hydrogen pressures just above atmospheric, but further improvements were obtained in cooling by raising the pressure of the hydrogen to several atmospheres. However, in these early designs heat from the windings had first to be transferred to the iron and thence to the hydrogen through the main ground insulation, and a point was soon reached at which the thermal resistivity of the slot insulation constituted the principal impediment to heat transfer. Little or no improvement in cooling effect could then be gained by further increases in coolant pressure.

To overcome this limitation, on all present-day generators of large size the cooling medium is carried inside the ground insulation and passes through ducts formed by various means in the copper winding. Cooling then becomes, almost entirely, a function of the thermal capacity and heat-transference characteristics of the gas and ventilating ducts, and a continuous improvement is possible with increase in hydrogen pressure.

Fig. 1 is a sectional view of a typical direct-cooled rotor winding in which a combination of radial and axial ducts is fed with gas from a subsidiary duct beneath the coil. Cool hydrogen enters the coil at frequent points along its length, through openings in the coil insulation. Provision is made by the use of additional insulation for adequate electrical creepage at the inlet and outlet ports. The rotor illustrated is self-ventilating, relying mainly on the centrifugal fan action of the radial ducts to circulate the hydrogen. Many alternative designs are in service in which hydrogen is circulated from the ends of the coil through the length of the rotor by high-pressure multi-stage fans. In other designs gas is picked up from the air gap through scoops on the rotor surface and forced into and along axial ducts in the winding, before being discharged through ports located at adjacent axial positions.

STATOR WINDINGS

Although the volume of copper in the stator windings is not limited by stress considerations, as in the rotor there are other limitations. Firstly, additional transport difficulties are introduced by increases in weight and diameter, as the copper section and depth of the stator winding is increased. Secondly, the depth of copper is restricted by eddy losses which become excessive in deep bars and require an increasing multiplicity of strands and winding transpositions.

The very thick insulation necessary on the high-voltage stator windings has a greater thermal resistance even than that in the rotor and some form of inner cooling becomes essential in machines of 200 MW and above.

Where inner cooling is applied to stator coils, the high working voltage makes it necessary to locate the inlets and outlets of the coolant ducts on the end-windings well clear of the earthed metal. In consequence the coolant ducts have to run from end to end of a comparatively long coil and the path of the coolant flow is many times longer than in the case of a rotor of the type illustrated in Fig. 1.

At first sight the use of hydrogen to cool the stator winding is particularly attractive, as small leaks from the coolant system are of little importance. However, the thermal capacity of gas is relatively small unless the density is increased many times by raising the absolute pressure, and high gas velocities are used to obtain adequate mass flow. The use of high gas velocities through the relatively small ducts makes it essential to employ some form of very high pressure fan, usually of the multi-stage type, to circulate the coolant.

Liquid as a stator coolant possesses the advantage that it has a high thermal capacity relative to gas, and the pressure required to produce the flow through hollow conductors is readily obtained from a pump external to the machine. The liquid can be supplied through a strainer and the ducts within the conductor can be quite small.

Water appears to be the nearest to the ideal liquid for internal cooling. Its specific heat is high and its viscosity is low. In practical arrangements the flow is turbulent and the temperature difference between the water and copper is negligible. Its capacity for heat removal is excellent, enabling it to produce very cool windings with very high current densities in the copper.

Machines of 30 and 60 MW with water-cooled stator windings are in service in Great Britain. The first, the Bold power station at St. Helen's, has been in satisfactory service since late 1956. Many more machines of this type are under construction. Fig. 2 illustrates a 200 MW machine with a direct water-cooled winding on the test bed. This machine will shortly be installed in the Willington "B" station.

The water is fed from stainless-steel manifolds to and from the ends of the hollow copper strands through insulating hoses of polytetrafluoroethylene, a material which is completely impervious to water and has a high resistance to arcing. Water of high purity with a very low electrical conductivity of about 5 to 10 reciprocal megohms per cm cube is circulated through the winding by an external pump.

Each conductor has a voltage to earth, rising from a small voltage at the neutral end up to phase voltage at the line terminal end; hence a small leakage current flows in the water columns. The power loss, however, is a minute fraction of the loss in the coil and is removed, together with the copper losses, in the circulating water. The water normally used has quite a low conductivity but in the machine illustrated the power loss in the water is so small that it would still be negligible if ordinary tap water were used.

To improve the overall efficiency of the set, the losses in the stator winding and those losses which are transferred to the hydrogen are partially recovered by circulating the turbine feed water through the appropriate generator coolers.

Stator winding voltages may be of the order of 25 kV and currents of 15,000 amperes or more. To remove such currents from the machine, gas-tight water-cooled bushings are

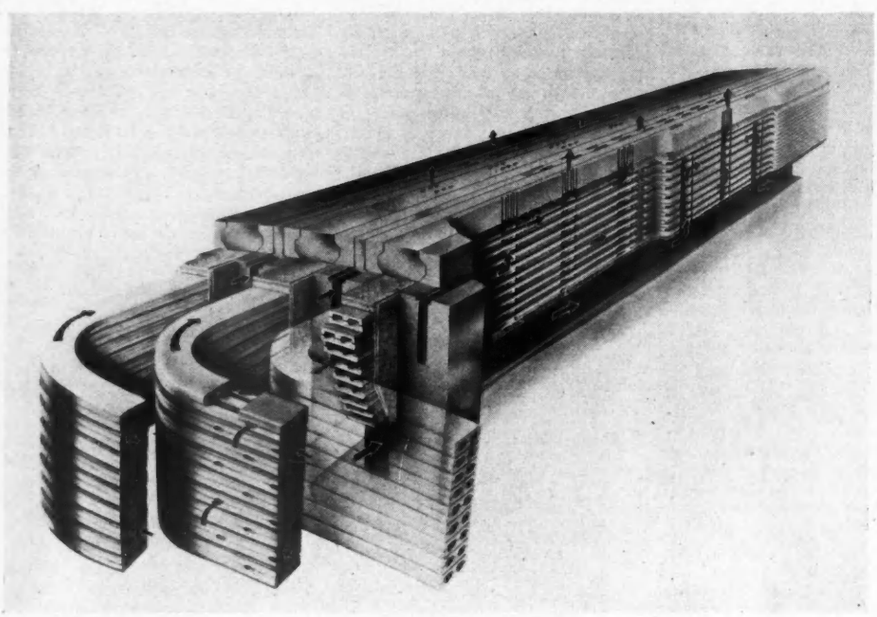


Fig. 1 Sectional view of rotor ventilation system incorporated in 200 MW and larger turbogenerators.

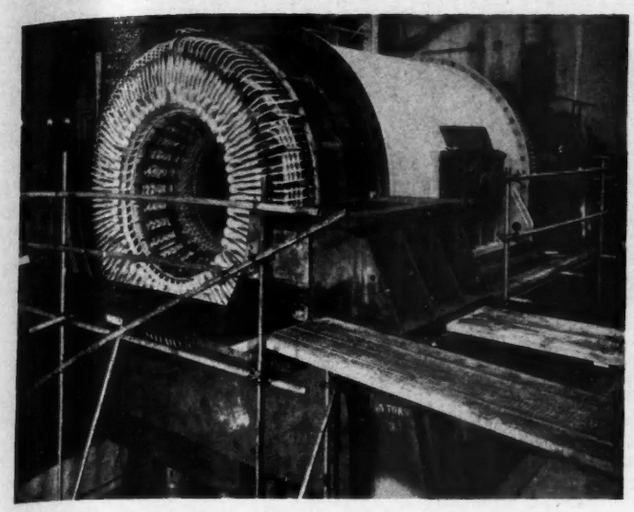


Fig. 2 200 MW AEI turbogenerator with water-cooled stator winding for Willington "B" station on the generator test bed.

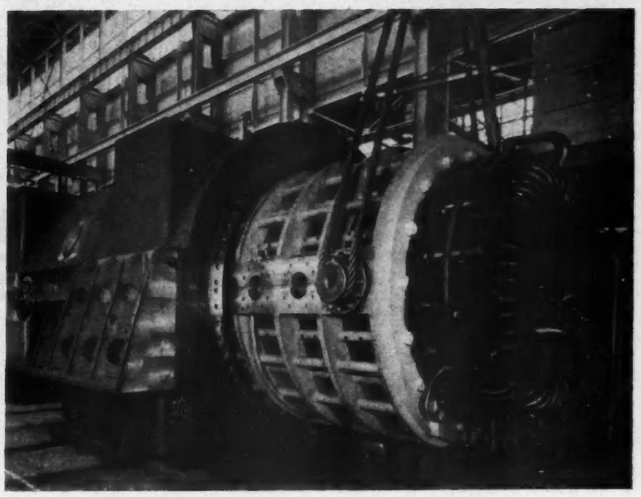


Fig. 3 Inserting the caged core and windings in a large hydrogen-cooled generator.

used. Although, up to the present, naturally cooled copper or aluminium busbars between generator and generator transformers have sufficed, water-cooled cables or busbars may soon be necessary.

STATOR ENCLOSURE

To minimise the weight and dimensions of the heaviest portion of the machine for transport purposes, the stator core and windings are often constructed separately, in a light cage, which is inserted in the outer gastight casing after the machine is received at site. This results in the minimum possible weight for transport of a complete machine, assembled and tested in the factory.

Alternatively, the hydrogen coolers may be built into separate sections at the ends of the frame and these are attached to the centre piece containing the core and windings after transport to site. Machines of this type are illustrated in Figs. 3 and 4.

The whole machine must of course be made hydrogen tight at the highest working pressure and, in addition to the tightness of the welded casing and various joints in the frame, oil seals are necessary where the shaft leaves for coupling to the turbine and exciters.

The stator core and windings are usually supported on some form of flexible mounting to minimise the transmission of double frequency vibrations to the foundations.

EXCITATION SYSTEMS

As generator specific outputs increase the excitation power increases more rapidly than the increase in output and many problems have arisen in the design of the excitation current collecting equipment and the exciting machines. Excitation voltages have risen to values as high as 600 volts at normal rating, but even so, currents of several thousand amperes must be transferred to the rotating field winding through carbon brushes and sliprings and thence through the collector leads to the rotor windings.

Careful design is necessary to ensure uniform current distribution between brushes and adequate cooling of the collector and leads. So many brushes are required and the working voltage is so high that conventional methods of brush replacement on load are not satisfactory and special detachable brush box units have been developed to facilitate removal and replacement of the brushes on the bench without the need to touch any live parts or to disconnect small terminals in close proximity to rotating machines.

As the excitation power increases the problem of designing large direct-current excitation generators becomes more difficult. To obtain high rates of exciter response under fault conditions, the exciter requires a high ceiling voltage and is in concequence a much larger machine than would be necessary solely to produce the excitation required at rated load. With increasing output the range of suitable speeds for the dc exciter decreases and hence a large and expensive slow-speed machine and gearbox is necessary. Hence, on many large installations at present under construction direct coupled alternating-current generators are to be used, feeding the rotor through static silicon rectifiers thus eliminating the gearbox and the exciter brush gear. Later developments may be expected to utilise rotating rectifiers supplied from an inverted ac exciter, thus eliminating brush gear entirely.

The conventional dc pilot exciter has also in many cases been replaced by an ac pilot exciter with excitation controlled by power transducters rather than the conventional main exciter field rheostat.

Present-day generators are designed with high values of synchronous reactance to minimise excitation requirements. As a result of higher electrical ampere turn loadings, transient reactances are also inherently high on the latest machines and may become limiting features in the largest machines. Satisfactory operation of modern high reactance machines is only made possible by the use of quick-acting automatic voltage regulators, having no deadband, which are able to maintain the stability of the machine in the leading power factor region and assist in maintaining stability under transient fault conditions.

Improvements in design of the combined generator, exciter and automatic voltage regulator system have combined to permit a threefold increase in the power to total weight ratio of turbo type generators and a fivefold increase in the power obtainable for a given transport weight. Whereas in 1953 the gross transport weight of a 60 MW generator stator and transporter was 160 tons it is now possible to transport the caged core of a 500 MW set within a gross transport limit of only 240 tons. These outputs have been achieved while maintaining relatively high generator efficiencies of the order of 98·4 per cent.

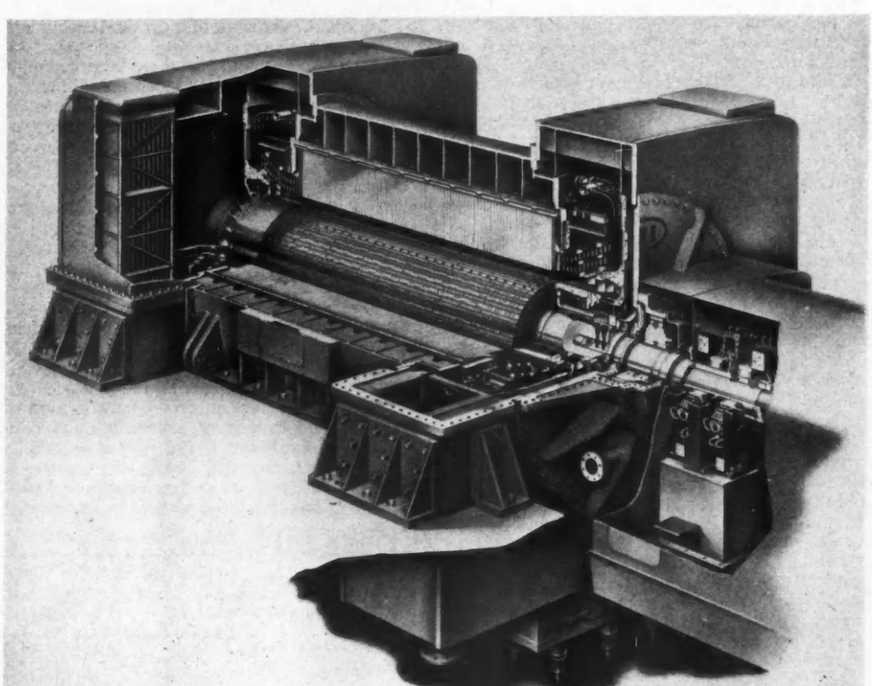


Fig. 4 Sectional view of a 200 MW hydrogen-cooled generator with water-cooled stator winding.

Supplying Electrical Energy in Bulk

Serving to pool the capacity of generating stations throughout the country, the Grid is also tapped directly as a source of bulk supplies.

By W. Casson, M.I.E.E.

Transmission Design Engineer, Central Electricity Generating Board

THE first commercial supplies of electricity were provided by supply systems based on local generating stations and there was no interconnection between those stations. As the load grew it was found that some of the original generating station sites were unsuitable for expansion and the supply undertakings concerned decided not to continue or to increase their generation but to obtain supplies in bulk from neighbouring supply authorities who possessed better generating resources.

DEVELOPING BULK SUPPLY POINTS

When the Grid came into being in 1929, as the result of the 1926 Act, the Central Electricity Board, in addition to fulfilling their primary function of interconnecting the generating stations throughout the country for pooling purposes, gave some supplies in bulk directly from the Grid system. The number of bulk supplies to undertakings without generation was being increased before nationalisation of the industry took place in 1948.

When this event occurred the supply system of the country consisted of a 132 kV and 66 kV Grid interconnecting a number of company and municipally owned systems, with or without generating stations, which had been developed in different ways according to the policy of their owners. None of these systems had been substantially reinforced during the war years and when the Area Boards took them over they were faced with the task of integrating and arranging them to permit economic development and to make the best possible use of existing plant and equipment. This work heavily taxed the resources of the industry at the time but gradually there developed distribution systems which were sounder in design, more efficient, and better able to meet the demand for electricity than would have been possible if nationalisation had not taken place.

The transmission system of the Central Electricity Board was relatively unchanged by nationalisation. The bulk supplies it had afforded to undertakings without generation now became bulk supply points to the Area Boards, except that where they were given at voltages below 132 kV (66 kV in certain cases) they were taken over by the Area Board as part of their system.

The Grid had already developed at nationalisation from a system for pooling of generation to one which also enabled generators to be operated in order of merit in respect of cost of generation. It was now considered to be the network from which new supplies to the area boards could be tapped to reinforce the distribution systems. This method had not been encouraged previously because of the imposition of an annual service charge for each new point of supply in the tariff.

NEW POINTS OR REINFORCEMENT?

At nationalisation, the Area Boards found themselves having some bulk supply points from the British Electricity Authority (the predecessors of the Central Electricity Generating Board), which were given direct from the busbars at generating stations having no direct connection with the Grid, others from " selected " generating stations connected directly with the Grid, and others direct from the Grid with no associated generation. The Grid then consisted mainly of a network of single and double circuit 132 kV lines. Some of these lines passed close to load centres, so that there was a demand for new supply points tapped off them where this would save the cost of heavy reinforcement of the distribution system from existing bulk supply points. (But tappings off the Grid could not be permitted in every case on account of the use for which the lines were required for through transfers of power required in connection with the pooling of generation and for affording economic supplies.)

Apart from requiring a number of new supply points, the Area Boards required reinforcement at existing supply points and it was soon apparent that a high degree of coordination would be necessary between the British Electricity Authority and Area Boards in the design of the transmission and distribution networks, if the whole was to be developed in the most economic manner. A joint planning procedure was introduced which ensured that the merits of expanding from existing bulk supply points were compared with the merits of providing new points feeding into sections of the distribution system carved off the existing system, and that the scheme chosen was the one which was economically and technically best, and provided most scope for future development. It also ensured that in preparing a plan for construction, the costs of the associated distribution charges were set alongside the costs associated with the transmission reinforcement, in order to arrive at the most economic arrangement overall, irrespective of whether the costs were chargeable to the Authority or the Area Boards, the point of demarcation of ownership being the point of connection of the bulk supply transformers to the busbars of the distribution system load. Since nationalisation it is claimed that many millions of pounds have been saved in the cost of reinforcing the national system by planning on this basis, compared with the method of expansion only at existing supply points.

In planning the needs of the area boards the Generating Board requires load estimates for each supply point. At these points the number of consumers is changing continually making it difficult for them to give precise information. In addition, the demands of individual consumers are constantly changing.

At each bulk supply point there is a maximum permissible capacity which does not allow for any unit, grid transformers or generation to be taken out, and a firm capacity which is the previous capacity minus the capacity of the largest generation unit and grid transformers. This is the figure which is normally used as a basis for planning and it allows for an overload, a factor which depends upon the type of connection. In arriving at this overload due account has to be taken of weak links in the circuits, whether in the grid transformer connections, lines or switchgear. Optimum planning should ensure that by the time the reinforcement is ready for commissioning the load at peak during the coming winter will be equal to the assessed firm capacity with overload. To realise this ideal requires accurate knowledge of the time taken for construction of the plant and equipment concerned, and continuing load expansion at the estimated rate.

Before the Generating Board was created in January, 1958, while there was a long-term plan for generation requirements, there was no similar plan for transmission requirements, which included the reinforcement of bulk supplies. Recently this shortcoming has been corrected and a long-term plan has been introduced, for both generation and transmission, in which schemes for reinforcing existing bulk supply points and providing new points are classified Definite Schemes (to be commissioned four years ahead), Provisional Schemes (five years) and Tentative Schemes (six years). With this plan, once a scheme becomes definite the construction work must proceed without interruption except in special circumstances.

TAPPING THE GRID

The Area Board, in requiring a new point of supply to reinforce their distribution system in a particular locality, would naturally select the position for the reception of the supply at the point which suits them best, after creating a new section of systems carved out of the systems supplied from existing supply points. In doing so they might provide for interconnection between the new section of system and modified sections of the existing system, so that adjustments could be made in the load to be supplied from any particular supply point, thus enabling best use to be made of the transformer capacity provided.

While a potential point for an infeed may be convenient to the Area Board, it may not necessarily be so to the Generating Board. There may be no transmission line in the vicinity and so a new line would have to be provided to give the supply. This new line might be made an extension or T-off of an existing line or be taken to the nearest transmission switching station and switched off the busbars. When overhead, it would be of double circuit construction. Where it becomes an extension or T-off, no switchgear is usually required at the terminal point other than isolators, each transformer being connected directly to the line but switched on the low-voltage side. Such circuits are known as transformer feeders and are preferred in most cases where there are site restrictions.

If a transmission line passes close to the preferred point of infeed, each of its circuits could be tapped by connections to transformers, with or without switchgear, in the same way as transformer feeders. If, however, one circuit only were tapped to provide a two-circuit bulk supply, then the circuit to be tapped would require to be broken and coupled by a circuit-breaker with the new outgoing circuits connected on each side; this procedure would create what is known as a one-switch station. Two more circuit-breakers could be added to the outgoing circuits to give better control, so providing a three-switch station. The switchgear in these stations could be located separately from the transformers or be combined with them, which is the more usual case. To facilitate maintenance, isolators are required on each side of the circuit-breakers and in the circuits to the transformer and lines. The space occupied by a typical 132 kV outdoor substation is 320 ft by 180 ft. More space would have to be allowed for future expansion.

Such an installation could cope with an

TABLE:—*Standard Sizes, Reactances and Tapping Ranges for Grid Transformers*

Ratio	132/11 kV		132/33 kV					132/66 kV		
Rating, MVA	15	30	30	45	60	75	90	45	60	75
Impedance, per cent ..	20	20	10	12·5	12·5	15	17	12·5	12·5	15
Connections	Star/Star	Star/Delta						Star/Star		
Tapping range	+10 to −20 per cent, in 18 steps of 1·67 per cent									

Note.—All the above transformers are provided with forced oil air-blast cooling (OFB) and above ratings specified are with forced cooling, the maximum continuous rating with natural cooling only being 50 per cent of these ratings.

infeed into the Area Board system up to about 100 MW, the stages of development during 20 years being say two 30 MVA transformers initially, replaced by two 60 MVA transformers in 10 years time, and later by two 90 MVA transformers. When the load reached the full capacity of the transmission line it might have to be pegged by hiving off sections of the system to other supply points at intervals.

In considering such a development, the Area Board would have to decide on the short-circuit rating of the low-voltage switchgear to be employed at the bulk supply point, and in view of this decision might decide to put in switchgear initially which would not require to be changed up to the point of maximum infeed. In the case quoted above, this equipment would probably be rated at 750 MVA. On the other hand, they might select switchgear with a lower rating initially, say 500 MVA and then change later, perhaps after 10 years, to 750 MVA rating. This changeover may only, in practice, amount to modifications carried out on site. In addition to short-circuit levels, consideration would have to be given at the outset to the current-carrying capacity of the busbars and here again the Area Board may decide to provide a capacity which would suffice up to the full development of the installation.

A layout plan of an outdoor three-switch substation is shown in the drawing, in which it is seen that there are two transformers, namely 1 and 2. These are erected on concrete plinths and provided with external bushings for connections on the one side to the high-voltage circuit-breakers and on the other side to the bushings of cables taken to the low-voltage switchgear. The whole installation is surrounded by a fence.

A small building is provided on the site to house terminal boxes for control cables from the isolators and circuit-breakers, and for control cables to the control panels wherever these are located. The building would also house protective relay panels for the lines and transformers, together with an operating battery and the necessary alternating-current auxiliary supplies. An oil storage tank and purifying equipment might also be housed on the site.

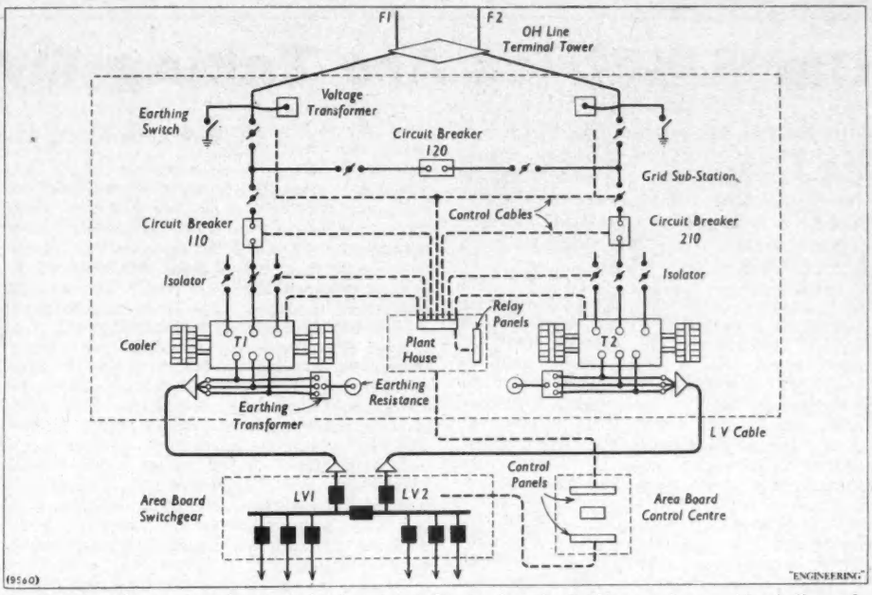
The cost of installation with 60 MVA transformers would be £275,000.

Changing transformers for larger units would require one circuit to be out of commission for the time taken to effect this operation. Meanwhile, the low-voltage cables for the transformer would also be reinforced. Changes of this kind are usually made when the load is lightest, in other words during the summer months. Transformers are brought on to the site usually by road vehicles. The old transformer is pulled off the plinth and the new one pushed on. The displaced transformers are available for use elsewhere and full use is made of them for reinforcing other supply points.

OPERATION AND PROTECTION

The high-voltage circuit-breakers of the Grid substation affording the bulk supplies would require to be closed and tripped remotely from a control point which may be a manually operated control room of the Area Board, where the Area Board low-voltage circuit-breakers at the bulk supply point are also controlled, or alternatively the control room of a nearby generating station. The control circuit connection would be provided in cables laid between the substation and control room, if separated for less than about a mile, but if the separation is greater hired Post Office wires would be used.

The control facilities would enable the operator to open and close any circuit-breaker and certain isolators and to operate the tap-changers of the transformers. In addition, the latter might be operated automatically. The Grid circuit-breaker and isolator operations would be carried out to the instructions of the control engineer located at the System Control Centre and would be required in connection with maintenance work or for restoration of supplies or circuits after a fault has occurred due to lightning,



Layout plan of an outdoor three-switch substation, indicating how the Grid is tapped to provide a bulk supply.

insulation flashover, or some other cause. Automatic operation is now being introduced on a large scale, to reduce the time taken to restore circuits when supplies have been lost and dispense with a manual control room which, apart from being expensive, involves a very dull ob for the staff concerned.

Equipment is required at bulk supply installations to afford protection against electrical faults of various types. For example, a fault could occur on any one of the three conductors of the two incoming lines, due to a flashover on the insulators at a tower, initiated by a lightning strike or caused by pollution. Similar faults could also occur on the connections in the substation and on the transformer bushings. On the low-voltage side of the transformers faults could take place in the cables due to breakdowns of insulation of the cable or joints.

To be effective, protective equipment must detect the fault in the shortest possible time and cause only the faulty piece of equipment to be removed from the system, leaving the healthy parts in service. For example, in the arrangement shown in the drawing for a fault on F1, circuit-breakers 110 and 120 should be tripped, leaving the load to be supplied through feeder 2 and circuit-breaker 210. Likewise, a fault on feeder 2 would be cleared by opening circuit-breakers 210 and 120. If the fault is on transformer 1, it should be cleared by switches 110 and LV1.

A modern high-voltage circuit-breaker can be designed to clear a fault in about 1/20th of a second and fast-operating protective gear could also be designed to operate in about that time, giving a total clearance time of say 0·15 second. A fault cleared in that interval would normally have little effect on connected load and would only cause a momentary flicker in lighting. However, not all faults can be cleared so quickly and protective gear has to be designed to clear every type of fault before serious damage or dislocation of supply can result and this requirement calls for very ingenious devices and techniques.

With a one-switch station, which would be the three-switch arrangement shown in the drawing, omitting the circuit-breakers 110 and 210, the transformers T1 and T2 would be teed directly off the lines so that, if a fault occurred on a line or transformer, say F1 or T1, the protective relays at the bulk supply point would open circuit-breakers 120 and LV1, and this would remove the fault infeed from the bulk supply point. However, if at the other end of F1 the protective gear had not operated to clear the infeed at that end, it would be necessary to provide inter-tripping (sometimes called transfer tripping) initiated from the bulk supply point to clear the fault. This arrangement would require the provision of a signalling channel between the bulk supply point and the substation at the other end of F1, which could be either a high-frequency signal passed through the high-voltage conductors or a specially provided " private " control cable, or a pair of wires hired from the Post Office.

It is possible to dispense with a communication channel for such an operation and have instead an arrangement at the bulk supply point which, when the protective relays of the transformers operate, in addition to opening the associated circuit-breakers at the bulk supply point, will cause a supplementary device to close and put a fault on the associated line so that the protective relays at the remote end will operate as though the fault were a line fault. This approach is called a fault throwing operation.

STANDARDISATION

Since nationalisation great progress has been made by the Area Boards and Generating Board in standardising the requirements at bulk supply points. Some of these improvements are as follows.

Voltages.—There was an early decision to standardise on the supply voltages 275 kV and 132 kV in the transmission system, and 33 kV and 11 kV for distribution points of supply.

Transformers.—The short-circuit levels found at supply points are in the main determined by size and reactance of associated Grid transformers. It was decided to have standard sizes, reactances and tapping ranges as shown in the Table. It was also decided to design the bulk supply transformers to have an overload rating which would provide a cyclic rating of 130 per cent of the nominal firm transformer capacity. It was finally agreed to use a figure 30 per cent more than the British Standard current rating of the transformer forming the firm capacity.

Short-Circuit Levels.—In order to limit the number of designs of switchgear it was decided to limit the short-circuit levels and the busbars at bulk supply points in general to maxima of 750 MVA at 33 kV and 250 MVA at 11 kV.

LOOKING FORWARD

With a load growth such that the demand is almost doubling on average every ten years, many more new bulk supply points to the Area Boards will be required each year and existing ones will need to be reinforced up to full capacity of the incoming circuits. It will thus be necessary to consider the use of larger sizes of transformers and increased short-circuit levels at the point of intake, than those at present standardised.

Car Electrics Are Taking Over New Tasks

Electrical systems, being flexible and easy to install, continue to assume new tasks in the working of the motor car; but the life-potential of different electrical components has yet to be harmonised.

By John Rabson, A.M.I.Mech.E., M.S.A.E.

TODAY there is a tendency to take for granted the large amount of equipment that is found in even the cheaper car. Yet when the motor industry was a little younger, many of these items were optional extras even for the more expensive models. Instruments, fog lamps, heater fans, screen wipers, rear window demisters, direction indicators, overdrive controls, cigarette lighters and many other items, not forgetting the radio, show how much we rely on electrical components in the car of today. With so many units relying on electricity to power them (including of course the ignition and starter motor) the electrical system as a whole has moved from its former role of desirable accessory to become a vital item of vehicle equipment, with a status equal to that of the mechanical components such as brakes, steering and tyres, although even in the days of hand starting and gas lamps there was no real alternative to some form of electric ignition.

The problems facing the electrical engineers responsible for automobile equipment are many and complex. Further analysis would show that they are collectively much more diverse than many facing electrical engineers working in other fields. Anyone engaged in automotive equipment manufacture must also pay particular attention to cutting costs.

AUTOMOTIVE AND AUXILIARY

Car electrical equipment can be divided into two categories: those components that are necessary in order to make the engine function, and those that perform ancillary duties while the vehicle is in motion—or parked with the engine switched off. This double purpose means that the electrical unit must provide power to operate the auxiliaries when the engine is not in operation, including the strenuous task of starting the engine from rest. It is the need to ensure satisfactory cold starting that very largely governs the size of battery required, and it must be remembered that vehicle manufacturers have to produce cars that will start without undue fuss over an extremely wide range of operating conditions. Not only must there be a battery to operate the starter motor and parking lights, it is also obviously necessary to provide a dynamo so as to ensure that the battery is kept in a satisfactory state of charge. At first sight it would seem a very simple matter to provide suitable charging equipment, but there are points which are sometimes overlooked.

With modern engines that can rotate at very high speeds, it is necessary to ensure that the dynamo will charge over a very wide speed range, and the drive ratio must be arranged so that it is low enough to prevent the generator from suffering ill effects if the car is driven long distances at very high speeds, yet it must rotate quickly enough to offset the demands made on it in slow-moving town traffic.

To complicate the problem further, the required electrical output can vary between very wide limits for a constant generator speed. For example, the car could be driven at 40 mph with no demand on the electrical supply other than that required for ignition purposes, and possibly the operation of an electric petrol pump, if it were fitted. On the other hand, the same car could be driven at the same speed, but providing electric power to operate two side lights, two headlamps, two rear lights, a number-plate illuminating lamp, windscreen wipers, radio, rear window de-mister, with perhaps occasional operation of stop lights, direction indicators, overdrive solenoid, and for good measure, a pair of wind-tone horns. Neglecting horns and heating equipment, this requirement could result in a load of some 300 watts which must be generated in addition to the ignition load and output needed to keep the battery charged.

However, with a modern electrical system, the average driver probably knows little or nothing about what is going on, and relies on his automatic regulator units to make the necessary adjustments and keep the battery correctly charged, without the detrimental effects of overcharging. By and large, the systems work well, or do they? Is the present system wholly satisfactory, or is the electrical equipment one part of the vehicle which the manufacturer in this country needs to examine closely in order to make sure that it is competitive in price and superior in quality?

All too frequently one hears of minor but irritating faults which are associated in some way with the electrical system—faults that are often neither difficult nor expensive to cure, if one happens to be wise enough to carry around likely electrical spares in the car. But they nevertheless cause annoyance and trouble, and do perhaps point to one important factor.

One talks easily about electrical failures, but is that, in fact, a correct definition? Except in a few isolated cases, one could argue that the failures which do occur are not in fact electrical, but mechanical. For example, if a wire breaks, it usually does so because it is not mechanically strong enough; if insulating material suddenly decides to conduct, that too can be considered as a mechanical or materials problem.

If this argument is accepted, and it is agreed that most of the so-called electrical problems are really mechanical failings, one must next seek the reason. Possibly the answer lies in the fact that good electrical engineers are not necessarily equally brilliant mechanical engineers (in fairness, the reverse may be equally true), and one solution to this problem is to look more closely into the mechanical side of vehicle electrics, to make sure that the good work done by the electrical engineers really does benefit the vehicle owner, who in the future will rely more and more on the electrics.

MORE ELECTRICS

The trend towards greater use of electrical components is very largely because of their flexibility, convenience and ease of installation. For example, the electric oil pressure indicator came as a considerable boon several years ago, because it enabled the solid connection between the engine and the facia panel, in the form of the oil pressure gauge pipe, to be eliminated. A small point, perhaps, but oil pressure pipes have been known to be responsible for curious (bush) telegraph messages being conveyed to the driver, causing alarm where none was justified.

How can electrical systems be further developed in the future? Perhaps the best way of finding an answer is to try to visualise what other items of equipment are likely to be fitted, over and above those already in use today, or what items at present operating mechanically could to advantage be operated electrically.

One item coming in the latter category might be the cooling fan. At high speeds this device can be noisy, and consume unnecessary horsepower, which must be paid for by the driver in his fuel bill. In fact, frequently the cooling fan is needed only when the vehicle is moving relatively slowly, and if an electric motor were used, it would be a simple matter to arrange automatic switchgear to stop it from rotating when it was not required. There is no novelty about this system, as it has already been used, but it does indicate one way in which the extension of the use of electric power might be advantageous.

In most other directions, the wider use of electrical equipment may take the form of refinements in control—automatic headlamp dipping being a case in point (provided that it is always fitted with an overriding control, and develops antibodies that eliminate spurious susceptibility, so that it does not react when confronted by the lights of street signs or reflectors). Another place where refinement of control may appear is in the heating and ventilating equipment, with some form of automatic temperature control device that is cheap, reliable, and is able to respond more quickly than the changing vehicle conditions, so that the car temperature could be set to a predetermined level which would be maintained as in house and office air-conditioning plant.

Further developments are taking place with even the basic electrical equipment of the car, such as the ignition system and the generator. It will be remembered that in Automobile Review on 6 January, reference was made to an ignition system which used neither coil nor battery—these units being replaced by a spark pump. This device, which was exhibited at the last Smithfield Show, produced a spark by mechanical pressure stressing a pair of crystals; and if such a component could be produced in a form that would give the required degree of reliability and life factor, its use might not only simplify the electrical ignition circuit, but would also facilitate starting, by reason of the reduced load on the electrical system. Alternators are being developed, with a view to their replacing the present direct-current generator, and they may well be more compact and better able to withstand high-speed operation.

UNIFORM RELIABILITY

Looking even further into the future, there is the question of automatic vehicle guidance. Radar and the automatic pilot are used to aid navigation and increase safety for other forms of transport, and already thoughts are turning towards the possibility of such devices being used, although perhaps in very much modified forms, for road vehicles. The test track of the Road Research Laboratory has already been laid below the road surface, with metal strips which can be used in conjunction with the appropriate equipment mounted in the vehicle, and although it may be a number of years before such devices might be considered for use in production vehicles in this country, it does clearly indicate that in the future the standard of reliability for electrical equipment may well need to exceed that of any other part of the car.

It should not be thought that present vehicle electrical components are unreliable. Generally speaking they meet the demands made of them in a satisfactory way, and it could often be argued that improved life or greater reliability would mean increased weight and cost—battery capacities might be a case in point. So often it is a question of reaching a satisfactory compromise to ensure trouble-free operation for a given life. This in turn means that for any vehicle it should be the aim to provide a balanced life-span. If this can be achieved, then no one component or set of equipment should earn a reputation for unrealiability on a given car. But if similar basic components are used on a variety of cars in widely differing price brackets, each having a different life-potential, the component manufacturer's lot is not a happy one. Is the solution to standardise to a larger degree on overall vehicle life factors, based either on time or distance? The policy of insured battery life is perhaps one step in this direction.

Nuclear Contenders

THE contract awarded for the seventh nuclear power station at Sizwell, to be built for the Central Electricity Generating Board, brought the total power produced by Britain's nuclear stations to 3,000 MW. This is about 10 per cent of the country's present total generating capacity. The interest that the CEGB has shown in building nuclear power stations has been an inspiration to many countries. It may be asked whether we are putting too many eggs into one basket by building seven stations, with further additions likely, all of the same type and considered by many to be out of date. This is a typical "sitting on the wall attitude" and the CEGB is to be commended for the lead that it has taken. Economic improvements and higher efficiency will also result from the experience that the consortia can have with one reactor type. Although the advantages of the Advanced Gas Cooled Reactor and the High Temperature Gas Cooled Reactor appear to be numerous, there is still a large amount of research to be done to solve the many associated problems, and this takes considerable time.

Closing the Gap

With a calculated life of 20 years, and it is expected that this will be exceeded, the present type of station will have filled in a wide gap, during which much experience and knowledge will be gained. Also the longer that the present stations can be kept running, the better, so long as maintenance does not become an expensive item, since this will be spreading the capital cost over a longer period. This will reduce the cost per kilowatt and hence narrow the already dwindling economic gap between the nuclear and conventional fired stations. Too much emphasis must not be put on the figures that appear for the cost per kilowatt of installed capacity, until actual figures are available from a running plant, but the estimated reduction from £160 for Berkeley to £90 for Sizewell is worthy of speculation. With the introduction of new types of reactors this figure promises to drop considerably more.

Station	Capacity (MW)	Contract Awarded	Full Load	Contractors	Section of CEGB
Bradwell	275	Dec. '56	1961-62	TNPG	Southern Project Group
Berkeley	300	Dec. '56			
Hinkley Point	500	Sept. '57	1963	APG*	Northern Project Group
Hunterston	300	Dec. '56	1963-64	GEC	Scottish Central Electricity Generating Board
Trawsfynydd	500	Aug. '59		APC	Northern Project Group
Dungeness	500	July '60	1964-65	TNPG	Southern Project Group
Sizewell	550	Dec. '60	1965-66	APG*	Midland Project Group
Oldbury	550	Dec. '61	1966	—	Southern Project Group
Anglesey	800 ?	Late '62 ?	—	—	Northern Project Group

* English Electric—Babcock & Wilcox—Taylor Woodrow Atomic Power Group.

An interesting comparison is the difference in architectural design between Calder Hall and the model of Sizewell shown. It would appear unfair to say that the latest nuclear stations are unsightly in spite of their unwieldy size.

A review of the stations follows giving the present state of construction and a recent photograph of each.

Bradwell

The civil engineering work is practically completed on this site. The first reactor has the graphite in position and also the charge-discharge machinery. The control rod installation is well advanced and the safety circuits are being cleared; it is hoped to start dynamic testing of all the equipment by the end of the month. Fuel loading will begin in the middle of May and it is expected that the reactor will be on load in November of this year.

The second reactor is about six months behind the first; the graphite laying is approaching the halfway mark, while the pile cap area is being fitted with the various items of equipment, and the first charge-discharge machines are being constructed. All six boilers have been tubed and the six gas circulators are nearly finished.

The cooling pond is undergoing tests with water and will be complete before loading fuel into the first reactor.

In the turbine house five of the six 52 MW sets are completed and work is proceeding on the last one: the house will be complete by the time that the first reactor is generating power. The last of the three 15 MW auxiliary turbo-alternators supplying electricity to the blowers is being put into position, and on the cooling water side testing of the system is in progress. The whole station should be operational by the middle of next year.

Berkeley

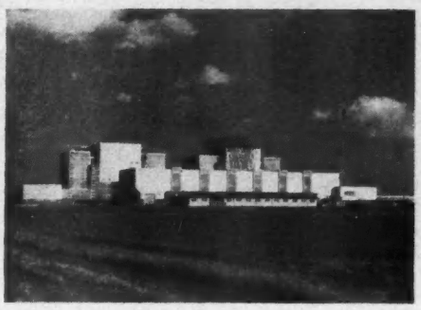
The civil and mechanical work at Berkeley is now virtually complete and the emphasis is on the completion of electrical installation of the No. 1 reactor. Due to strikes by the ETU recently, 4 to 5 weeks have been lost on this side of the construction and there is a drive to put it back on schedule. The circuit system of the first reactor, which includes the pressure vessel, boiler and ducting, has been pressure tested, and the carbon dioxide blowers have been run at speed. The charge-discharge machines are all in position and have been tested together with the reactor controls and safety mechanisms. At present the gas flow speeds through each of the 3,275 channels in the core are being checked using air to ensure that the correct amount is passing through each. In the middle of March the majority of tests will be repeated with the reactor at the normal running temperature and pressure. Fuel, which has been arriving from Springfields refinery since last November, will start being loaded into the core at the end of April. The loading procedure will last approximately three months together with further necessary tests, and the reactor is expected to be on load in October. The cooling pond will be finished by the end of May.

No. 2 reactor is between six to eight months behind the first and has been held up, but to a smaller degree, by the ETU strike. However, the station should be fully operational by the middle of next year. The pressure vessel is now complete and has been stress-relieved and pressure tested. The blowers and boilers are in position together with the charge-discharge machines, and the graphite laying has reached the half-way mark. The cooling water system is also complete.

The turbine hall and the four 83 MW turbo-alternators are near completion and the first half of the building will be ready by the beginning of May. Full electrical tests are being made in the main control room.

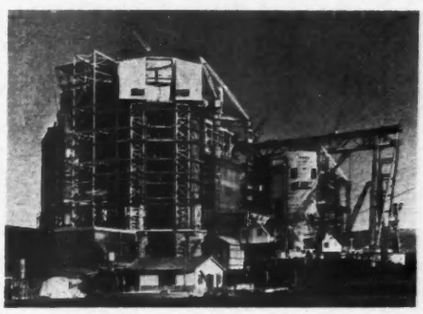
Berkeley Research Laboratory

A new research laboratory costing over £2 million is nearly completed at Berkeley and will be opened in May, by which time there will be a staff of 350 people working there. The factor of a fully operational station being on the site will prove a very useful facility for research.



Bradwell: General view from the banks of the Blackwater. The first reactor and cooling water pump house are to the right. (The Nuclear Power Group—TNPG).

Berkeley: The first reactor in the background and the turbine hall on the right. In the foreground are the operation offices and the maintenance workshops which are already in use. (TNPG).



Hunterston: Five of the steam raising units are now in position on the first reactor (left), and the internal installation has begun in two of the units. (General Electric Company Limited—(GEC).

Hinkley Point: All twelve heat exchangers are now in position. The 100 ft turbine hall is on the right, and part of the switchyard is shown on the top right hand corner. (English Electric-Babcock & Wilcox-Taylor Woodrow Atomic Power Group—APG).

Some members have already begun the work which they will continue at the laboratory by working the the present in other established laboratories. When the staff have settled in at Berkeley they will work in close cooperation with the operational and maintenance personnel of the station. It is to be hoped that the CEGB will not spend too much of their resources investigating new types of systems but that their main aim will be to make nuclear power economic as soon as possible. It is the job of the UKAEA who have better resources and equipment to investigate new systems. Emphasis must be laid on the need for close cooperation between the two bodies which is often a failing with government concerns, since the situation could present an ideal stage for two large bodies becoming totally independent, resulting in a gross waste of manpower and money.

The new laboratory has approximately 100,000 sq. ft and will include physical, instrumental and material sections—the work they will cover will be as wide as their titles suggest.

Hunterston

The pressure vessel of the first reactor is now being prepared for stress relieving and the heating elements are being erected and the thermocouple points prepared. About a quarter of the bottom head has been externally lagged with 6 in thick insulation. All the control rod nozzles have been welded and are being inspected; and the standpipes will be fitted after the stress-relieving. Inside the vessel, the pipes carrying carbon dioxide gas for the cooling of the inner surface are being fitted. Graphite laying will begin in October this year and the reactor is expected to go critical in August, 1962.

The support grid of the pressure vessel in the second reactor was lifted into position last month and shortly the third course of the vessel itself will be placed in position. The criticality date for the second reactor is May, 1963. This means that there is a gap of about ten months between the two reactors, however, due to experience gained on the first reactor production is ahead of schedule on the second. Five steam raising unit shells associated with the first reactor have now been lain on their plinths, and work has begun on the installation of the gas circulators and the tubing inside two of the vessels. In order to do this it has been necessary to erect a "clean condition" building on top of each shell. Foundation steelwork of four of the six 60 MW turbo-generators is being erected in the turbine hall; the first condenser has also been installed and successfully pressure tested. The first turbine has been tested at the Erith works of GEC and the second is in preparation. The six circulating water pumps and their 800 hp driving motors have been installed in the pump house.

Hinkley Point

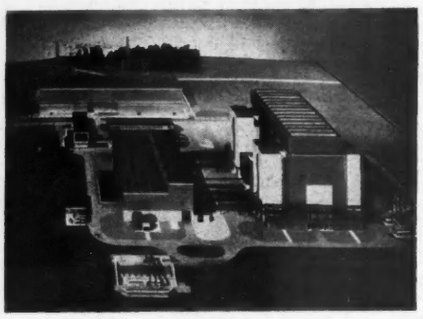
The biological shields of both reactors are complete apart from the pile caps. In the first reactor the pressure vessel is complete and has been stress relieved: it is now being pressure tested at 310 lb per sq. in and 30 ± 5° C. Following this the standpipes will be welded into position, and the complete vessel cleaned for graphite loading to begin at the end of June. The loading of fuel into the core will take place towards the end of next year and the station will be on full load in 1963, about 12 months behind Bradwell and Berkeley.

In the second reactor the sphere is nearing completion and the nozzles for the standpipes, fuel loading mechanisms and control rod mechanisms will be welded on to the pressure vessel and blanked off for stress relieving and pressure testing of the vessel at the end of April. After this no more welding is done on the vessel. Overall there is a delay in the construction between the two reactors of about six months.

All 12 boilers are erected and the blowers are in the process of erection. In the turbine hall the condensers for the first three sets are in position, and the turbines are still at the manufacturer's works. The cooling water pumps and the tunnels are complete and the intake was recently floated out into the Bristol Channel.

Trawsfynydd: Construction work on the first reactor progresses on schedule with the engine room steelwork in the background. (Atomic Power Constructions Limited—APC).

Dungeness: On the left is the excavation for the reactors, centre for the steam connecting pipes and right for the turbine house. (TNPG).



Sizewell: The model shows the turbine hall on the left and the reactor building flanked by its boilers to the right, with the indoor switch gear building in the background. (APG).

Trawsfynydd

Work on all mechanical plant in the station is on schedule, and the original contract date of October, 1963, for the first reactor to be on full load should be met. The bottom half of the pressure vessel has been completed and is in position in the biological shield, while the upper half is now having the nozzles fitted, and should be completed by the end of May when the upper section of the vessel weighing some 400 tons will be transported to the biological shield to complete the sphere. Previously the majority of radiography of the welded seams on the vessel has been carried out using a cobalt 60 source, however, at Trawsfynydd a 4·3 MeV linear accelerator (Atomic Review, 6 Dec. '60 and 3 Feb. '61) has been introduced, instead of using the more conventional cobalt 60 source.

The construction work on No. 2 reactor is still in the very early stages. The first boiler will be lifted on to its plinth in about six weesk time. These boilers are erected in strakes delivered to Portmadoc Harbour, and construction is completed in site workshops. Before being placed in their plinths, the boilers are stress relieved in oil fired furnaces and hydraulically pressure tested.

The structural steel of the engine room and the associated control room and switchgear annexes is being erected. One of the features of the Trawsfynydd design is that the cladding of the building will comprise precast concrete slabs, the external surfaces of which are finished in local stone. The station uses the artificial lake as a source of circulating water and the cooling depends on natural radiation from this lake. The steel pipe for the cooling water system has now been completely welded, and embedded in concrete.

Dungeness

Over 600 men are employed on the construction work at Dungeness by Sir Robert McAlpine and Sons Limited. Since the site is on an open shingle beach with the water level only 10 ft, below the surface, it has been necessary to surround the whole area with a girdle of interlocking steel piles. The steel pile girdle, involving some 2,500 piles, was driven to a depth of 45 ft and 38 wells have been sunk within the enclosed area, some as deep as 135 ft. Pumping has started and will continue for 18 months—the present rate is 100,000 gallons per hour. The concrete raft for the first reactor is now complete and the second is being poured.

Sizewell

With the contract given to the English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group last December for a 580 MW station with two reactors scheduled to come into operation in 1965 and 1966, there is now a pause until work begins on the site in April.

Oldbury

Tenders were invited for this station in October of last year after the Minister of Power had given consent for the construction of a 550 MW station at Oldbury in Gloucestershire. Tenders are due in August of this year and it is expected that work will begin early in 1962 for completion in 1966. Preliminary work has just commenced in order to provide a reservoir for the cooling water of the station. Advantage is being taken of rock shelf offshore to create an artificial tidal reservoir of 350 acres which will impound water at high tide.

Wylfa in Anglesey

Application was made to the Minister of Power in December last for the consent to establish a nuclear power station at Wylfa in Anglesey. The proposed capacity is not to exceed 800 MW, but this does not mean that the CEGB will finally build a reactor of this size. The commissioning date is given as 1967, and it is expected that the station will be similar in design and type to its predecessors.

Hamstead, Isle of Wight

No further news is available on the possibility of building a nuclear station at Hamstead in the Isle of Wight. This was found to be the only site suitable for a nuclear power station development between Dungeness and Weymouth. Due to possible effects that a station may have on the landscape, it has been decided to explore the alternative of a conventional station.

Reactor Notes

Fuel for NS Savannah: Initial shipment has been made of $9 million (£3·19 million) worth of nuclear fuel for the NS Savannah from the Babcock and Wilcox plant. The delivery of 36 fuel elements will last for seven weeks.

Italian Nuclear Tanker: Fiat and Ansaldo are studying plans for a nuclear powered tanker with a cargo capacity of 47,000 tons (Atomic Review, 17 Feb. '61). The reactor is a pressurised water type, and will be fuelled with 6,000 lb of uranium oxide.

Companies

Fifty Years On for BEAMA

IN ITS jubilee year BEAMA, the BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION, is as heavily engaged in urging the case for the electrical engineering industries, in furthering the industries' export efforts, and in education and training developments as at any time in its 50 year life.

In the export field BEAMA has taken two steps in particular that stand out from the mass of day to day affairs. These were the export conference on the heavy electrical side and the similar meeting for appliance manufacturers.

Marketing know-how, shared experience of foreign competition, the special requirements of particular overseas markets, these are the substance of the exchanges, formal and informal, at such get-togethers.

The electrical manufacturers' case, whether presented by individual company spokesman, by the industry's leading directors, or by BEAMA, is well enough known. It is that the super-long production lines, and the long into the future planning that is necessary if British washing machines and refrigerators are to be competitive cannot be organised unless there is a stable home market.

"As we have repeatedly said," BEAMA's director, Mr. S. F. Steward, told ENGINEERING, "the industry needs a stable market. When credit controls are suddenly taken off, or sharply brought back again, this sort of planning, without which it is not possible to meet the intense competition, becomes impossible."

Unimpressed

The recent increase from two years to three in the period for hire purchase repayments has not particularly impressed the electrical domestic equipment makers. They urge that the deposit should go down to 10 per cent. Most of all they want to see it staying there.

It is not an exaggeration to say that the plea for stability is as strong as that for the smaller down payment at the time of buying.

BEAMA is not solely concerned with representations on the conditions of trade. In education and training it seeks to wield its influence in the educational organisations, and with government departments and to maintain the electrical industry's full participation in both the training and recruitment of engineers, scientists and technologists.

Representatives of the industry sit on the Hives Council, the Regional Advisory Councils for Technical Education, the City and Guilds of London Institute and the British Association for Commercial and Industrial Education. They are there, too, on the education committees of the Federation of British Industries and the Institution of Electrical Engineers. BEAMA took a leading part in the formation of the Electrical and Electronic Manufacturers Joint Education Board.

The committees of the association, where a great deal of quietly essential work is done, are a useful quick guide to the width of BEAMA's concerns. The committees, in addition to those titled Emergency and General Purposes and Finance, are:

- Contract Conditions
- Contract Price Adjustment Clause and Formulae (CPA)
- Education
- Electric Welding Industry
- Export Panel
- Materials
- Mining and Flameproof Enclosure Materials
- Nuclear Energy
- Publicity and Exhibitions
- Standardisations
- Traffic
- Domestic Appliances Board
- Domestic Appliances Divisional Export

The knowledge and experience of conditions of contract in Britain and throughout the world accumulated by BEAMA in some 50 years of work is recognised in the way in which other bodies ask for consultation and assistance. The association's conditions of contract have become internationally established and model conditions used by the industry at home and overseas are published by BEAMA.

Strenuous and Exhilarating Campaign at RTB

The net profit before tax of RICHARD THOMAS AND BALDWINS in the last financial year rose by 60 per cent. This was in a year of high demand with the turnover up by almost a fifth.

In the current year's first few months there has been some general easing in the demand for steel sheet and tinplate and lower prices in the export markets. Giving these facts in his annual statement the RTB chairman, Mr. G. C. R. Eley, recalls that the price of one of the main raw materials—coal—has been "abruptly increased" and there is likely to be a consequential effect on the cost of electricity and perhaps of other services. Wages have risen and the Iron and Steel Board have decided that these increased costs shall be borne by the steel industry.

The situation thus emerges that profit margins are being reduced both from above (earnings) and from below (costs). And this at a time when there is a check to turnover. Mr. Eley reports that none of the current massive development schemes with which RTB are engaged will make a material contribution to the profits in the current financial year.

Unless there is a recovery in demand, trading profits are likely to be lower this year. From these profits will also have to be provided higher interest and other charges on the Llanwern steelworks and other projects.

In the year up to 1 October, 1960, the RTB turnover rose by 18½ per cent to £103,500,000, the trading profits by 45 per cent to £14,757,725 and the net profit before tax to £11,188,733.

Capital expenditure, largely on the Spencer works at Llanwern, rose from £9 million in 1958-59 to £37 million. Capital spending this year will be even heavier. There is no possibility of any let-up in the immense RTB development plan over the next two years and Mr. Eley sums it up when he says that the management is: "taking part in a strenuous and exhilarating campaign."

On the future prospect the chairman says: "the steel industry cannot, of course, command outstandingly good times. There must be periods of hesitation, and of consolidation, or of activity in circumstances of lower profit margins; but in the medium and longer-term we are confident that we can expect an ever-growing demand for our products."

New Works Medical Centre at Ebbw Vale

Pushing ahead with their great new Spencer works, RTB are also spending heavily at Redbourn, Panteg and Ebbw Vale. At Ebbw Vale the recent opening by Mr. H. F. Spencer, the RTB managing director, of a new medical centre underlined how despite the company's low accident rate for the industry the medical service receives the same carefully thought out provision.

Most of the services given by a hospital out-patients department are available at the new Ebbw Vale works medical centre. The main surgery, now replaced, with its four satellite surgeries around the 2½ miles long works, had

some 100,000 attendances during last year.

Throughout the year there were only 227 accidents among the 11,000 personnel causing men to be absent from work, and most of them were minor in nature.

Three full time doctors are based at the works, each now provided with his own consulting room. For minor injuries there is a large general treatment room. A resuscitation ward, with three beds, is there to cope with the more serious cases. The physiotherapy department has modern equipment sufficient to meet last year's demand for 8,000 patients.

The preventive programme includes the selective placing of personnel, medical superivision intended to maintain high standards of health, control of environment using the occupational hygiene team and public health control in cooperation with local medical officers of health.

The three doctors also cover the RTB works at Panteg, Pontymister and Abercarn, where permanent surgeries are staffed by nurses. The total medical service staff in addition to the doctors is made up of a sister-in-charge, 22 nurses, 8 rescue men, 2 hygiene supervisors and a physiotherapist.

New Elliott Subsidiary to make Rotron Flowmeters

The full range of instruments for positive and mass-flow measurements in the oil, gas, water and petro-chemical industries developed by the ROTRON CONTROLS Corporation of New York, USA, are to be produced in Britain by a new subsidiary set up by a member company of the ELLIOTT-AUTOMATION Group jointly with the New York corporation.

Commonwealth Sales

The new company, to be known as ROTRON CONTROLS Limited, will be jointly owned by ELLIOTT BROTHERS (LONDON) and the Rotron Controls corporation. Elliott's will have as two-thirds controlling interest and the headquarters will be at the Elliott, Automation Airport works, Rochester Kent.

The subsidiary will handle the sales of the flowmeters and their associated equipment in Europe, the Middle East and the British Commonwealth (except Canada).

The rotational speed of a vortex created outside the mainstream, and directly proportional to the rate of flow of the fluid in the pipeline, is measured by the Rotron flowmeters. This method is said to give a substantially more accurate measurement than meters normally in use for this measurement.

Industrial Development in North Wales

TAYLOR WOODROW CONSTRUCTION have been made the main contractors for the new FERODO factory to be built on a 50 acre site two miles from Caernarvon, North Wales.

The full project will cost about £2½ million. The company's expansion in Wales is being accompanied by a capital investment scheme costing £1 million at the Chapel-en-le-Frith, Derbyshire, headquarters.

Taylor Woodrow's contract is on "all-in service" lines. It covers design, construction, electrical, heating, ventilating as well as other installation. Plant and equipment is expected to be moving into the new works by the late autumn and the estimated date of full completion is in April of next year.

The full range of Ferodo's woven brake linings and clutch facings and non-slip stairtreads will be produced in the North Wales factory. Initial employment will be in the region of 500 people and this is expected to expand to 1,000 later.

Softening the Outline

The new works will be only a few miles from the Snowdonia National Park and considerable care has gone into the planning and the final appearance. Trees are to be planted between the buildings and the foreshore of the Menai Strait, screening the north-west elevation from the island of Anglesey. Further planting will be carried out between the Bangor-Caernarvon road and the Bangor-Caernarvon railway line to break up the outlines of the factory. Colour schemes and the use of local material have been planned to blend as far as possible with the district.

The factory's production block will be single-storey, 29 ft high and 800 ft long by 300 ft. The works will be the largest single user of the gas, water and electricity services in the area. The extent of the factory's gas consumption has led to the decision to build a 3½ mile pipeline to supply gas at high pressure from the grid. The local rural district council is undertaking a major scheme to bring water from the River Seiont.

Reyrolle Class LMT Switchgear

There are about fifteen British firms making air insulated switchgear in the 6·6 to 11 kV voltage range. In recent years fresh thought has been put into general design.

IN SUCH a competitive field as switchgear, it is necessary for each manufacturer to decide on a policy which gives his particular products a definite place in the market. He might choose high quality, quick delivery or low price as his main axiom, to name but three.

Reyrolle have 75 years of experience behind them and are probably the largest firm devoted to switchgear production in the world. They have a reputation to uphold and, not unnaturally, they have chosen quality as their keyword.

But quality alone is not sufficient in itself to ensure the success of any particular article, as other Product Profile surveys have revealed. While a customer is often prepared to spend money on quality, there is always a limit to the price he is prepared to pay for it. This limit will depend upon what is meant by " quality," or in other words what it will offer the customer in return for his money.

Switchgear is functional rather than spectacular —a kind of electrical Cinderella, not concerned with either of the much more glamorous tasks of creating electrical power or using it to drive a machine. Switchgear is merely a link, albeit a vital one, in the complex transmission network between electricity's generator and user. It possesses no running parts and is not subject to quests for increased efficiency, higher rotary speed of operation nor the application of automation. In this case quality simply means good engineering, and its application to switchgear is resulting in equipment of more compact design and more pleasing appearance.

To inquire into the subject, ENGINEERING visited A. Reyrolle and Company Limited, Hebburn, Co. Durham. Shortly after nationalisation the Electricity Boards set up joint committees with industry to decide on standardisation policies for all types of equipment. It was not unnatural that Reyrolle should be one of the firms called in to represent the switchgear industry due to their influence in this field.

One range of equipment on which it was decided to standardise was the switchgear used to control the 11 kV distribution systems so common in the United Kingdom.

SPECIFICATION S2

One of the tasks facing the 11 kV switchgear standardisation committee was that of deciding what operational features were acceptable or desirable, over and above a specified electrical performance. Arranging the closing mechanism of the circuit breaker to correspond with downward movement of the handle, and standardising the mechanical interlocking and the position of instruments and relays on the front facia were among the points considered important.

In 1955 the committee's findings resulted in the issue of specification BEBS-S2 by the British Electricity Boards for standard distribution switchgear of 150 MVA rating at 6·6/11 kV and 250 MVA at 11 kV. Individual switchgear manufacturers then reviewed their designs as it was appreciated that it would take some time before all requirements of the specification could be met. Rather than modify an existing design Reyrolle felt that they should adopt a different policy. They decided that what would count in the long run would be the equipment that offered manufacturing flexibility to cover requirements outside the scope of those demanded by S2. The specification only applied to British electricity undertaking requirements, while Reyrolle had a large established overseas market to consider, to say nothing of industrial users.

The decision to offer maximum facilities meant that research and development work would probably take longer than their competitors could afford to wait. However, since LMT switchgear was introduced about two years ago, time is proving that the reward of success was worth waiting for. Furthermore, the company were also governed by a sense of responsibility to the customer arising from their long-established reputation. They were reluctant to introduce a new product before thorough research, testing,

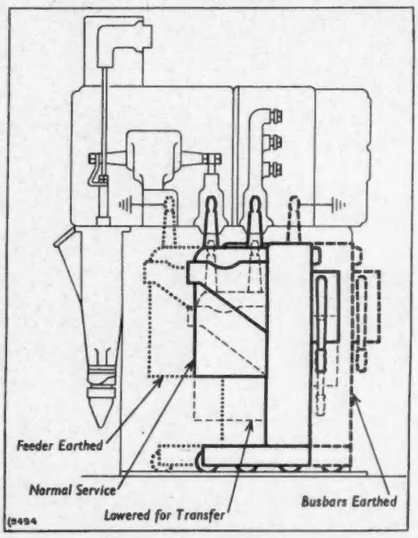


Fig. 1 (above) Transfer system of earthing.

Fig. 2 (below) Circuit breaker carriage.

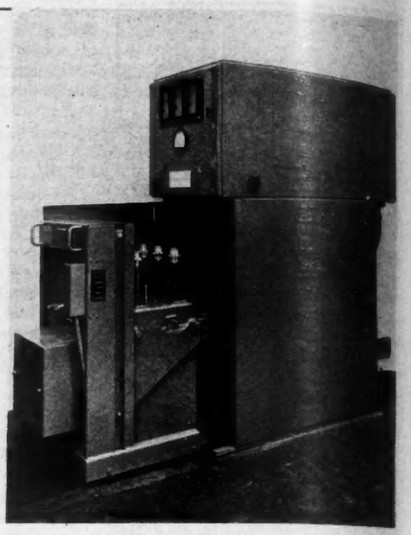


Fig. 3 The cubicle is 5 ft 2 in high, 23 in wide, and the depth with breaker withdrawn is 7 ft 9 in.

and where necessary, redesigning, had been carried through. To this factor must be added the conservative nature of the switchgear in the past, which made it all the harder to break away from tradition in design.

Reyrolle actually started the development work which led to the birth of class LMT about 1950, five years before publication of S2. It became increasingly obvious that the new equipment would have to be tailored to a definite economic level. The importance of a price ceiling was due to the fierce competition that could be anticipated, particularly overseas. The company realised that new materials provided the answer to both the degree of refinement and the pruning of production costs that they required. It is the skilful use of new materials in conjunction with new insulation techniques that has made class LMT possible in its present form and has assured its success. Furthermore, development work on new materials is a continuous process, and did not end with the introduction of the new range.

DESIGN FEATURES

In this country and in many others where British influence predominates in the electrical field, 11 kV is a common distribution voltage for urban areas. In countries under American influence, however, other slightly higher voltages are common, up to 15 kV for basic distribution work. So Reyrolle designed class LMT so that it could readily be adapted for service at voltages from 3·3 kV up to 15 kV.

The next decision was to use the principle of vertical isolation. This feature had been used by Reyrolle in an earlier 11 kV range during the war, and allows a neater mechanical layout than the more conventional horizontal arrangement. In conjunction with vertical isolation a horizontal transfer system of earthing was employed, as shown in Fig. 1. The circuit breaker portion consists of a welded steel carriage to which the circuit breaker top plate is bolted, mounted on four flanged wheels. A central screw geared mechanism operated by a removable handle is provided for raising and lowering, see Fig. 2.

As with many other kinds of product, styling has become important in the success of electrical equipment generally. The use of sheet steel cubicle construction welded and stiffened offers good mechanical strength together with a fashionable appearance.

One of this gear's strongest points is its

Fig. 4 Where good engineering involves the full use of new materials and techniques.

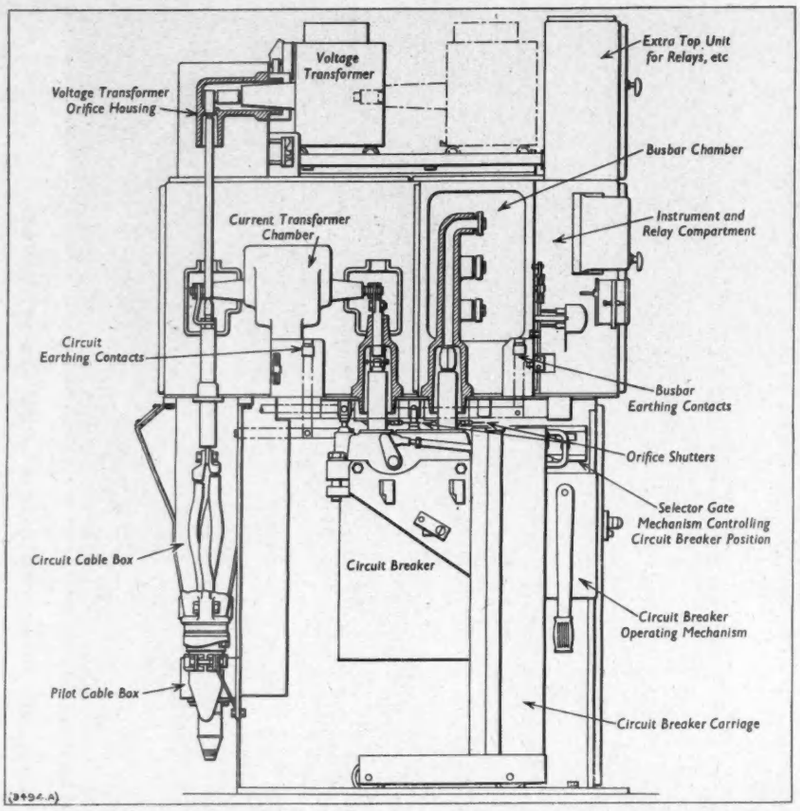


Fig. 5 Feeder or transformer cubicle.

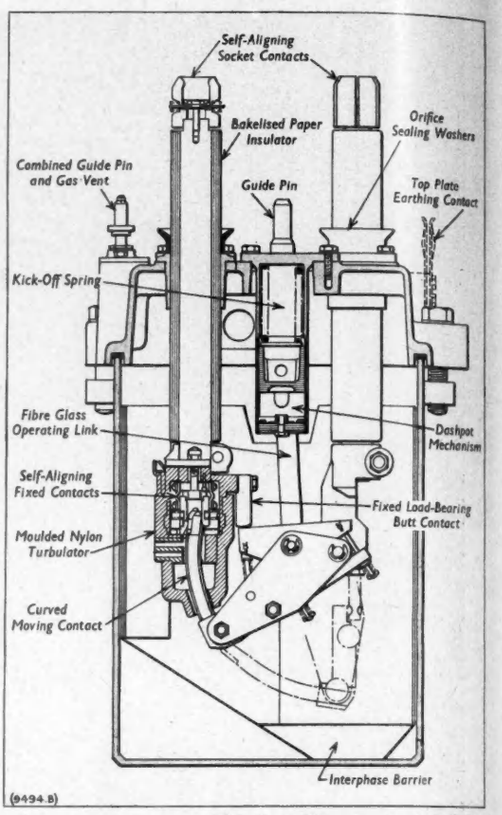


Fig. 6 1,200 amp circuit breaker.

compactness and lightness compared with equipment for comparable duty designed a few years ago. It is not necessary to stress the advantages of saving space. The functional volume of space required (the volume required for installing, operating and maintaining the equipment) is only about half of that required for correspondingly rated horizontal drawout gear. The improved insulating materials and the adoption of the transfer system of earthing are two important contributions towards compactness.

Special attention has been given to the design of the electrical components to minimise the phenomenon known as "discharge," which is detrimental to the life of any kind of insulation.

The circuit breaker is oil-filled and can be rated for 400, 800 or 1,200 A depending on customer requirements. It is of the single-break design with wiping contacts and a moulded nylon turbulator arc-control device.

The orifice, busbar and current-transformer insulators are silicon-filled epoxy resin castings produced in Reyrolle's own works, and replace the conventional and bulky porcelain insulators. One big advantage of thermosetting plastic insulation which is extensively used is that it is self-sustaining, and can be moulded to shape around any preformed conductor. This eliminates many problems associated with normal conductor-to-insulator jointing and often simplifies insulator-to-casing fixing.

The hinged facia plate of the relay box has been designed to give the impression that the relays are flush mounted, though they are of the projecting type mounted on an internal recessed plate with cut-out windows in the facia plate to match. In fact the whole cubicle has been designed for accessibility from the front to suit a multiple installation, of which Fig. 4 illustrates a good example.

Reyrolle have incorporated into the design facilities for the maximum number of variations to suit the particular customer. The range of voltages and different current ratings have already been mentioned. Sufficient internal space has been provided to accommodate current transformers of many ratios outside the scope of the S2 specification. The same cubicle can be used equally well to house an oil filled switch instead of a circuit breaker, and units with either an extensible or non-extensible oil break switch mounted on each side for Tee-off ring main service are available.

Although the positions of the instruments and relays are in accordance with S2, their number varies with the application. If more than three relays are required an extra top unit can be added. The voltage transformer when required is carriage mounted on guide rails fitted on top of the current transformer and busbar compartments. Two of the units shown in Fig. 4 have both.

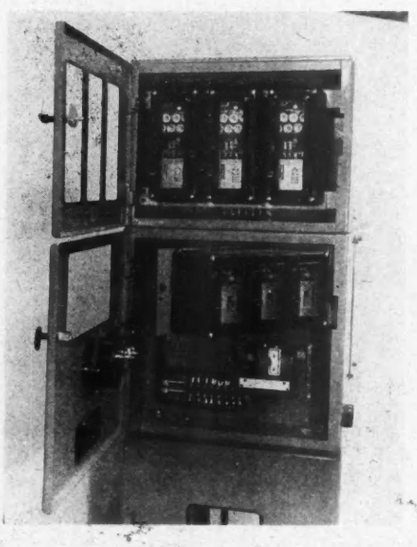


Fig. 7 Easy access to instruments and relays.

In the course of a visit to the LMT assembly line at Reyrolle's works ENGINEERING's representative was impressed by the number of different combinations of ancillary equipment that the company offer, using the same basic cubicle.

THE COMPANY

Reyrolle employ over 8,000 people in the two neighbouring establishments at Hebburn and the works occupy a total of 54 acres. Labour relations are excellent and over 400 employees have 25 years or more continuous service behind them. Switchgear in the lower voltage ranges is only a part of the firm's activities, and equipments rated as high as 300/400 kV are now under construction. They have their own research and short circuit testing facilities, and are renowned for high class workmanship and good service to the customer.

How does the class LMT range fit into the general pattern of Reyrolle's products? It is a comparative newcomer that has not yet displaced any of its predecessors because in the interests of standardisation earlier designs must still be retained in production for extension of existing systems.

The favourable reception which class LMT switchgear received at the time of its introduction was a sure pointer to its success, particularly at a time when a recession in home orders was affecting the switchgear industry. At present about 25 per cent of class LMT production is sent overseas, and additionally it may be manufactured under licence abroad. Reyrolle confidently expect a big future for the new range and line assembly has been introduced at Hebburn to cope with the growing market.

Long term trends in 11/15 kV switchgear could gradually see a swing towards air break instead of oil filled circuit breakers. Present techniques favour an oil filled system, and a major breakthrough would be needed before the air break design becomes economic.

Improved Protection for Electric Motor Windings

Encapsulation of electrical equipment is normally done by a casting process and can employ waxes, rubbers or resins. Two very desirable materials are cold-curing silicone rubber and epoxy resin, but other than for protecting delicate electronic equipment it has not been widely used on heavier industrial equipment.

Thus it is interesting to see that Newman Industries Limited of Yate, Bristol, are now encapsulating with epoxy resin the stator windings of all types of their open and closed electric motors from 1 to 125 hp.

Encapsulation renders the motor windings completely impervious to attack by moisture, oil and most chemicals. At the same time the windings are also protected from mechanical damage caused by the abrasive action of airborne solids.

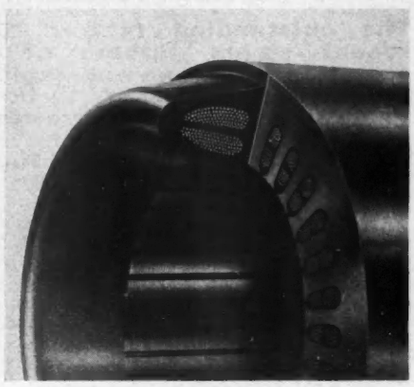
In developing the process, difficulty was experienced in finding a resin which was resilient enough to withstand repeated expansion and contraction of the stator windings over their normal operating temperature range, without cracking or breaking the seal to the stator core. The resin formulation finally selected has been well tried and proved by more than five years of development and field tests and is found to have the necessary characteristics for effective encapsulation.

Particular advantages are found in encapsulation for both the open drip-proof motor and the totally enclosed motor. Encapsulated drip-proof motors can often replace totally enclosed motors in applications where resistance to chemical fumes and moisture is needed. In fact, tests have proved that encapsulated open motors are often more satisfactory, because an enclosed motor "breathes" and so sucks in fumes which make contact with the windings.

Newmans stress, however, that their encapsulated open drip-proof motor is not intended to replace totally enclosed motors operating in very dirty conditions, where solid particles are liable to clog the air gap between the stator and the rotor in an open motor.

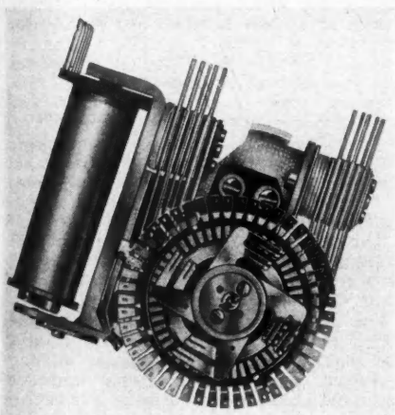
An advantage of encapsulation of the windings in the Newman totally enclosed motors is that they are protected against the effects of breathing in damaging fumes and condensation which is not uncommon in this type of motor.

The introduction of encapsulation will not affect the production of the company's normal range. These will continue to be made in sizes ranging from 1/16 hp to 600 hp.



The stator windings of the motor are completely enclosed by epoxy resin encapsulation

Three-in-One Rotary Stepping Relay



Combination of three components in one gives unusual versatility to this rotary stepping relay.

A combined stepping relay, rotary switch and relay has been introduced by the Special Products Division of Thorn Electrical Industries Limited, Great Cambridge Road, Enfield, Middlesex. It is a combination of (1) a standard relay with a knife-edge armature pivot operating contact springs and a ratchet and pawl driven stepping mechanism; (2) a ratchet driven rotary switch consisting of 4 banks of 12 points each with sliding bifurcated spring wipers; and (3) a ratchet driven stepping relay with 2 cams which open and close double contact type springs in accordance with the cam pattern.

This three-in-one device gives unusual versatility and compactness—the unit being little larger than a conventional relay. It has many applications and will be suitable for automatic test equipment requiring programming, sequencing, or memory storage. Relatively low power consumption makes it suitable for remote control and telemetering.

Each bank of the rotary switch terminals comprises a quadrant of the circle and contains a common bus which is connected to the 12 isolated points in sequence by a sliding wiper as the switch is operated. The four bifurcated sliding wipers are made of phosphor bronze and the wiper contact assemblies are insulated electrically from each other. The contacts of the rotary switch bank are capable of carrying 0·5 A on a steady state basis and of interrupting 0·1 A at 50 V dc with a resistive load.

There are also two pile-ups with a maximum of four springs each, which open and close with every step of the rotary stepping relay switch. All the contact springs are of the long leaf spring type with supports to ensure long life and trouble free operation. The twin noble metal contact points are capable of handling 1·0 A steady state and of interrupting 0·5 A at 50 V dc with a resistive load.

Coil voltages are 12, 24, 48 and 110 V dc. Two standard coils are available: (1) a high speed low inductance coil capable of stepping the switch at a rate of 40 steps per sec (power requirement 4 W) and (2), a more sensitive low speed inductance coil capable of stepping the switch at a rate of 20 steps per sec (power requirement 2 W). Life expectancy is between 5 and 6 million operations.

Propeller Turbine for Light Aircraft

Pressing ahead with the development of their small gas-turbines, the Rover Company Limited, Solihull, Warwicks, have just introduced two models for light aircraft.

Designated TP/60 and TP/90, the basic units are their 60 and 90 bhp industrial models which have proved reliable and easy to maintain under widely varying climatic conditions. Of benefit to light aircraft will be the vibration free characteristics coupled with low maintenance requirements, accessibility and long life. The units are very compact, measuring only 30 in long by 27½ in high by 20 in wide. Complete weight is 235 lb including propeller and accessories.

Maximum rating for the TP/60 is 70 bhp at 47,000 rpm giving a power to weight ratio of 0·255 hp/per lb. For the TP/90 maximum bhp is 120 also at 47,000 rpm and this gives a power to weight ratio of 0·383 hp per lb.

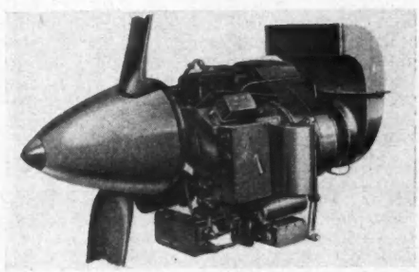
Each of the models has a single stage centrifugal compressor, one combustion chamber, and a single stage turbine. The compressor has two side air intakes. The single sided impeller has 17 vanes. The turbine wheel is of Nimonic 90 (105 for the TP/90). Inlet temperature is 800° C and exhaust temperature 600° C (650° C for the TP/90). Kerosine or diesel oil can be used and delivery is through a multi piston pump with a centrifugal governor. Reduction gear brings the output shaft speed down to 2,325 rpm.

No suitable variable pitch propeller was available for the TP/60 so Rover developed their own operating mechanism. The blades were supplied by Hordern-Richmond Ltd. of Gloucester.

Blade roots are retained by ball thrust bearings, and the pitch movements are synchronised by bevel gears. The propeller hub is mounted on taper roller bearings on the drive shaft, and is free to rotate within the limit stops. The bevel synchronising pinion is rigidly mounted on the drive shaft so that if the hub rotates in advance of the drive shaft, the pitch will increase. If the hub lags behind, the pitch will be reduced. A link mechanism connects the hub to the drive shaft flange in such a way that an increase in torque tends to reduce the pitch of the blades.

Centrifugal balance weights are secured to the links, so that an increase in rotational speed of the propeller assembly tends to increase the pitch. A torsion bar is connected between the shaft and the hub in order to give a bias towards fine pitch. Thus, having determined the values of the centrifugal weights and the torsion bar setting to suit the characteristics of the engine, the power absorbed by the propeller is constant at a given rotational speed, irrespective of the velocity or the attitude of the aircraft.

Because of the greater power output of the TP/90 engine the variable pitch propeller unit is not suitable. It is envisaged that to maintain simplicity a hydraulically operated variable pitch propeller will be required.



The Rover TP/60 gas-turbine has already been tested in a Currie Wot single seater biplane.

Current Trends in Steam Turbine Design

The outstanding feature of recent steam turbine construction has been the rapid increase in size of turbo-generator units. This growth in unit size could not have been achieved without full application of research.

By R. Ecker, B.Sc.(Eng.), A.M.I.Mech.E.

Steam Turbine Division, English Electric Company Limited

THE reason for the continuing increase in unit size of turbo-generators (see Fig. 1) is economic. As soon as larger generator units are available, larger steam turbines are constructed to drive them. Larger turbine units are inherently more efficient due to reduced parasitic losses and, in addition, the increased size helps to justify the application of more "expensive" but more efficient steam conditions.

From Fig. 2 the present worth of the coal saved by generating electricity in four 500 MW units instead of in twenty 100 MW units can be read off. It will be seen that large sums of money are involved, the precise amount depending on the actual cost of coal over the next 30 years, actual rates of interest, and actual load factor. In addition there are also savings in first cost due to reduced cost of construction per kW. This trend is indicated in Fig. 2 by the weight per kW, which is being reduced as the unit size goes up.

As unit size increases there are corresponding savings on other items of power station plant (boilers, buildings, etc.), but the need for strong and reliable interconnection, calls for a higher capacity transmission system capable of efficient transfer of larger blocks of power.

The savings due to larger unit sizes can only be realised if they are at least as reliable in operation as the smaller units already proven in service. This requirement is constantly before the designer.

STEAM CONDITIONS

Recent years have shown little change in steam conditions called for by the CEGB and this has been fairly common throughout the world. In order to acheive in practice the desired availability of plant, and because of the relatively higher cost of plant for 1,100° F and supercritical pressures, steam conditions for sets over 200 MW have been pegged at 2,300 lb per sq. in gauge at 1,050° F with single reheat to 1,050° F.

Pressures up to 2,300 lb per sq. in gauge can be reliably generated in a drum type boiler with which there is much successful service experience. Temperatures of 1,050° F have been successfully used with known combinations of ferritic and sometimes with austenitic materials in the boiler and such temperatures do not require any austenitic material in the turbine. It is considered that pressures higher than approximately 2,500 lb per sq. in gauge would be too near the critical for stable operation of a drum type boiler. Temperatures of 1,100° F and over would call for more expensive austenitic material on the boiler and also some in the turbine. Hence 2,300 lb per sq. in gauge at 1,050° F with single reheat to 1,050° F.

Fig. 1 Increase in unit size of tandem turbo-generator sets plotted against year of design.

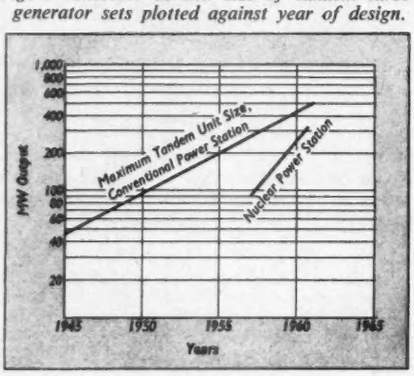


Fig. 3 shows a section through a 3,000 rpm turbine which is typical of the 275 MW, 350 MW and 375 MW tandem turbine units now on order with the English Electric Company. The 375 MW unit is not designed for the above steam conditions, but is the first of the two prototype large supercritical turbines in Britain for 3,500 lb per sq. in gauge at 1,100° F reheating to 1,050° F and will contain austenitic nozzle boxes within the double casing on the hp cylinder as well as austenitic chests and provision for some simple steam cooling on the rotor.

Relatively few sites are now available in Britain with ample supplies of circulating water in the vicinity of cheap coal. Consequently, most of the large stations are now being sited near pitheads with wet cooling-towers, operating at an average vacuum of 28·7 in. A prototype dry cooling tower installation is now being erected at Rugeley, Staffordshire, and when the design is proven in service it is expected to find useful application in Britain and abroad.

LAST LP BLADING

In order to take maximum advantage of prevailing vacuum conditions, efficient last blades are necessary. The turbine shown in Fig. 3 has four flows of LP blading using 36 in blades on the last ring, operating at 3,000 rpm.

The design and manufacture of such long exhaust blades is a major engineering development. English Electric have been leading the 3,000 rpm field in this respect for some time, being the first with the 22 in blades for 60 MW units, 27 in blades for 100 and 200 MW units, and now with 36 in blades for 275 to 500 MW units. The development and testing of these blades is reported on page 303.

Fig. 4 shows the centrifugal pull on, and tip velocity, of blades of various length. In its time each blade length represented the best it was then considered possible to achieve. These curves illustrate the progress which has been made both by metallurgists and engineers. The lower curve indicates the difficulty of the flow problems which had to be solved in order to ensure maximum efficiency of operation. The tip of the 22 in blade moves at practically sonic speed, the tip of the 27 in blade now in operation on the 100 and 200 MW units exceeds Mach 1·1, and the tip of the 36 in blade has been developed to operate at Mach 1·4.

TURBINE EXHAUST SIZES

The turbine exhaust annulus which can be offered with 3,000 rpm units is larger than the annulus which can be offered with 3,600 rpm units in the ratio of $\left(\frac{3,600}{3,000}\right)^2$.

The 20 per cent difference in operating speed means that rotors of equal size have to withstand 44 per cent higher stresses at the higher speed. It also means that for equal stresses permissible with the best known materials, 3,600 rpm designs have exhaust annuli approximately 44 per cent smaller.

Since the turbine leaving losses are very approximately inversely proportional to the square of the exhaust annulus it is not surprising that relatively high leaving losses of the order of three per cent are not infrequently met on 3,600 rpm machines.

With 50 cycle and with 60 cycle designs, cross-compound units can be used when the unit size required exceeds the maximum size of available generators. Cross-compounding requires two generators, and by using two generators of the maximum size the combined output is doubled in what are virtually two turbine lines operating as a unit. Cross-compounding can of course also be arranged with unequal splits of power between the two lines and also with a 2-pole generator in one line and a 4-pole generator in the other. Such arrangements, though not as cheap to build as single line units, offer many economic advantages as is shown by the fact that large 450, 500, 600 and 800 MW cross-compound units are now installed or on order in the USA, and two 550 MW units are on order in Britain.

INTERCONNECTION AND TWO SHIFTS

A very special feature of the British electrical system is the comprehensive interconnection of generating stations. The total installed capacity now exceeds 32,000 MW and is growing rapidly at about 7 to 8 per cent per annum. A system like this can easily use very large single turbine units since for instance a 500 MW unit represents only 1·56 per cent of installed capacity.

By comparison with the approximate 32,000 MW of the British electrical system, approximately 12,000 MW is believed to be the largest interconnected system in the US, but there the economic advantages of large turbo-generator units have been so attractive that several cross-compound units larger than 350 MW have already been put into service. Rapid progress of interconnection between adjoining Power Utilities can now be reported and there are also electrical tielines between the USA and Canada.

On the continent of Europe and in Russia the trend towards interconnection in selected areas is also resulting in purchase of much larger sets than those used in the past. Many 150 MW units are now in service and tandem units of up to 300 MW are under construction.

The electrical demand in Britain is heavy during the day and relatively light at night. The logical consequence of having an interconnected system is the two-shift method of operation, i.e., when load demand is reduced by say 10 per cent then 10 per cent of the least efficient plant is completely shut down. With

Fig. 2 2,000 MW station. Present worth of coal saving with a few reheat units instead of twenty 100 MW reheat units. Also showing specific weight of reheat set.

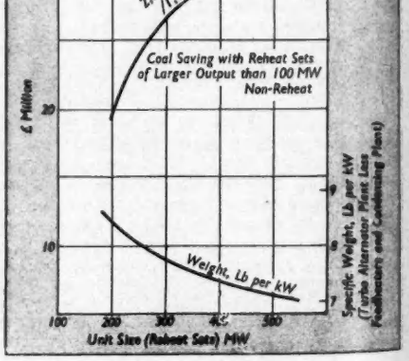
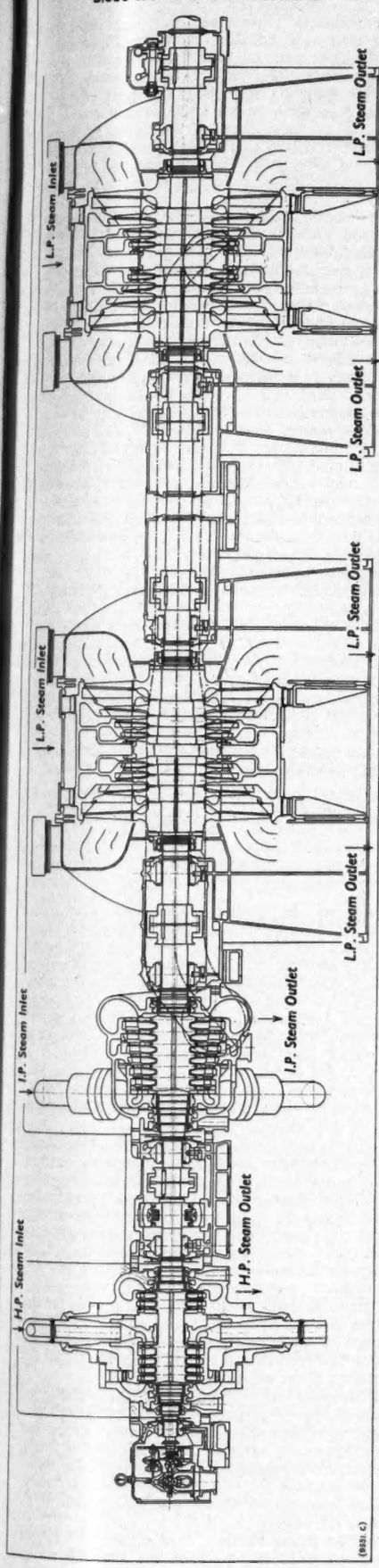

2,000 MW Station - 60% Load Factor
30 Years Life 89% Boiler Efficiency
5½% Interest 5% Station Auxiliaries
70/- per Ton of Coal of 10,000 BTU per Lb Calorific Value
100 MW Reference Unit 1,500 Gauge/1,050°F Non-Reheat
2,300 Lb per Sq In Gauge /1,050°F /1,050°F
Coal Saving with Reheat Sets of Larger Output than 100 MW Non-Reheat
£ Million
30
20
10
Weight, Lb per kW
9
8
7
100
200
300
400
500
Unit Size (Reheat Sets) MW
Specific Weight, Lb per kW (Turbo Alternator Plant Less Auxiliaries and Condensing Plant)

FIG. 3 CROSS-SECTION THROUGH 3,000 R.P.M. STEAM TURBINE



this method of operation the sets are either at full load or shut down completely. They must, however, be capable of rapid starting up and shutting down and this represents a heavy operating duty by comparison with machines which are started up and remain on load for many months at a time. It has been found that the following special features of turbine construction are particularly important in turbines designed for two-shift operation. (1) Generous clearances between rotors and casings, (2) design of components resulting as far as possible in equal heating and cooling, (3) full steam admission is used. Multiple nozzle admission points are not necessary because sets do not normally operate at part load, (4) suitably designed double casings to ensure quicker and more reliable start-ups (at high turbine stop-valve pressures and temperatures), (5) generally robust construction of blading, rotors and casings with particular attention to the problem of maintenance of good alignment under all conditions of operation (e.g. two bearings are used to support each rotor separately), (6) full use of supervisory instrumentation.

English Electric 60 and 100 and 200 MW sets designed in this manner for 1,050° F inlet conditions have after a six hour shut down been run up to speed and fully loaded in 25 to 30 minutes.

BOILER FEED PUMP IN CYCLE

On units larger than 300 MW, the CEGB are arranging for a steam turbine drive for the boiler feed pump (bfp) using steam bled from the main set. Similar developments have been taking place in the USA and the different cycle arrangements possible have been the subject of several papers.

For boiler pressures of 2,300 lb per sq. in gauge the boiler feed pump absorbs an output of about 1¼ per cent of the main turbine output, with double pumping, and about 2 per cent with single pumping (approximately 5·4 MW for the bfp drive on the 350 MW unit).

It is considered at present that the reliability of turbine drives for the bfp units is greater than the reliability of motors and variable-speed hydraulic couplings. On 350 MW units, full advantage may be taken of the similarity of the part-load characteristics of the driving turbine and the bfp so that a single valve control is all that is necessary from 100 per cent down to about 50 per cent. Below that load the driving power for the bfp is greater than that of the turbine fitted with a single valve. Since the CEGB sets are not intended for operation at part load it has been decided to use the electric starting and standby pump up to about 50 to 60 per cent load and retain the simplicity of the single valve boiler feed turbine.

SUPERCRITICAL PLANT

Two 375 MW tandem units are now on order in Britain with steam conditions of 3,500 lb per sq. in gauge/1,100° F/1,050° F/28·7 in. It is probable that the overall economics of this advanced steam cycle are not vastly superior to the 2,400 lb per sq. in gauge/1,050° F/1,050° F cycle which uses more conventional boilers and a lot less (sometimes none) of the expensive austenitic steels. These supercritical sets will, however, provide an opportunity to solve fully the problems associated with employing austenitic components at the turbine inlet, both from the point of view of reliable construction and two-shift operation with once-through boilers. Thermal differential expansion and the rate of heating of austenitic components have to be allowed for and it may be possible that the turbine by-pass system, necessary for the stability of the circuits on the once-through boilers, may be particularly useful in providing means of achieving the desired steam temperatures at starting.

There are now several large supercritical high temperature sets in operation in the US and most of them employ a double-reheat cycle, which adds about 1 to 1½ per cent to the thermal efficiency. Although these sets are operating satisfactorily it is significant that according to very latest thinking in USA supercritical steam conditions would probably stabilise at 3,500 lb per sq. in gauge/1,000° F/1,025° F/1,050° F. Thus the most expensive steels will not be used on the boiler or on the turbine since the greater strength to rupture at 1,000° F would be available to withstand the highest pressure while progressively lesser pressures at the two reheaters are associated with increasing steam temperatures.

NUCLEAR STATIONS

Hinkley Point power station, ordered in 1957, has two gas-cooled reactors and six steam turbine sets of 93·5 MW capacity. The latest order placed by the CEGB is for the Sizewell 580 MW(net) power station having two reactors and two steam turbine sets of 325 MW capacity at 3,000 rpm. Because of the medium steam conditions at inlet to these turbines very large steam flows have to be handled. This presents a specially difficult problem at the exhaust end of the machine. For best overall economy under British conditions turbines of this type require 1·5 to 2 times as much exhaust area as the so called conventional sets of the same output. Because of greater wetness at the exhaust, by comparison with the advanced reheat cycles, special attention has to be given to the problem of blade erosion. Slow-speed 1,500 rpm units were compared in this respect with high-speed units employing a steam reheat cycle, and the latter arrangement has been found to be more attractive for Sizewell.

Pressurised-water reactors and heavy-water reactors are being developed in the USA and Canada respectively. Both types of reactor are associated with steam having very little or no superheat at inlet. Consequently problems of moisture extraction and erosion generally are very important on turbines installed in those stations. Water separators are widely used and live steam reheat is also employed to limit exhaust-end moisture. Because of the very large LP exhaust blade areas required, slow-speed 1,800 rpm turbines are generally employed. The reduced blade-tip velocities associated with the 1,800 rpm machines also help to reduce blade erosion due to moisture.

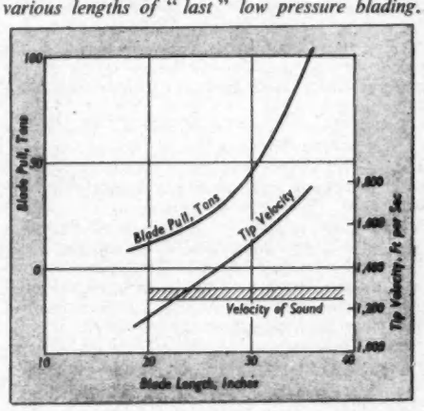
From what has been said it will be seen that rapid progress has been made in the unit size of turbines.

Four 500 MW single-shaft turbo-generator sets which will be the world's largest are about to be ordered by the CEGB for what is going to be the largest thermal power station yet constructed in this country or elsewhere.

There can be no prophecy as to how long the steam turbine will maintain its position as the prime mover of the electrical industry.

The present indications are that the thermo-electric or thermionic devices or magneto-hydrodynamic devices which are today receiving so much concentrated attention will only be suitable for "topping" the heat cycle. If this is so, the generation of electrical power in the "conventional" temperature range would most probably still be based on the application of very large steam turbo-alternators.

Fig. 4 Centrifugal pull on, and tip velocity of, various lengths of "last" low pressure blading.



On the Shelf

By Frank H. Smith

LUCKILY, I do not have to explain to my readership what the difference is between a contractor and a consultant, and as far as the Man in the Street is concerned he never hears of consultants and does not know what they are anyway. However, once in a while the consultants are able to blow their trumpets. For their diamond jubilee (1959), Merz and McLellan commissioned John Rowland to write their history (for private publication) under the title *Progress in Power*. For 60 years this firm has been behind the bringing of light (and power) to dark places. There is not an aspect of electrical consulting in which they are not expert and there are very few corners of the earth into which their work has not penetrated. The firm represents all that is best in British professional engineering and it is a pity that the book will not be more widely available than private publication will allow. True, its appeal is limited but it is another of those publications that could easily influence intelligent fifth formers dithering over a choice of specialisation in the sixth. Are you keen to get a copy? Then I will supply the addressses and you can try your luck. State your case to Newman Neame Limited, 50 Fitzroy Street, London, W1 (publishers), or Merz and McLellan, 32 Victoria Street, London, SW1. (the sponsors).

A little out of the run of bibliographies is a booklet from the Science Museum and obtainable from HMSO (423 Oxford Street, London, W1) at 1*s* 6*d*, called "Historic Books on Mining and Kindred Subjects."

At an annual subscription of £15 15*s*, to include 11 monthly parts and a bound annual volume, the Library Association (Chaucer House, Malet Place, London, WC1) invite you to indulge in *British Technology Index: a cumulative index to British technical periodicals*. 400 titles are contemplated for indexing and their gist will be on the desk of the subscriber within six weeks of publication. Tear off, they say, and return by 31 March. But that refers to the application form which you can get from LA. One word of warning. The index uses alphabetical subject headings. No numbers. Tut tut!

Lush as an oil company production is the new prestige magazine of the Pressed Steel Company Limited of Oxford. It is called *Picture Press*, and lucky the man who can make out a case to get it. (I shall try my luck, of course.) They even given three exotic recipes so arranged that they can be taken out and put in your wife's cookbook.

Henry Wiggin and Company Limited (Thames House, Millbank, London, SW1) issue a booklet on "Machining Wiggin High-Nickel Alloys," with which the film of the same name is associated. The film is hirable, the booklet is "on the house."

I quote. (*Soviet News*, 27 Jan.) Nikolai Akulov has discovered a law governing the plastic flow of metals. Let's see which of the cover-to-cover boys gets it on your breakfast table first.

From Aluminium Development Association (33 Grosvenor Street, London, W1) a "List of Films, Film Strips and Wall Charts." It runs to 28 pages and has a short explanatory note for each item. Free hire, of course.

After the recent Aslib/Society of Indexers pow-wow a man approached me and asked if I were the O. T. S. Smith. I weighed him up and decided he meant no harm, so confessed. All he wanted to say was that I had mentioned his firm's booklet and was first to do so and the local GPO had to lay on extra vans and get more sacks to cope with the rush. Send your stuff to Frankie, and get your handouts in the Top Ten.

Essence of Electrical Design

Schütze und Schützensteuerungen. By HERBERT FRANKEN. *Springer-Verlag, Heidelberger Platz 3, Wilmersdorf, Berlin.* (*DM* 42)

Lehrbuch der Hochspannungstechnik. By GUNTRAM LESCH. *Springer-Verlag, Heidelberger Platz 3, Wilmersdorf, Berlin.* (*DM* 39·60)

Die Nomographische Methode der Berechnung Komplizierter und Stark Gesättigter Magnetischer Kreise Elektrischer Maschinen. By OTTO BENEDIKT. *Hungarian Academy of Sciences, Alkotmány u. 21, Budapest, 5.*

Sitting at a desk piled high with manufacturers' leaflets and cuttings from the technical press, one occasionally dreams of an ideal world in which this mass of facts has been compressed into a small number of textbooks written by engineers for engineers. The specification for such books would include a clear style, a logical presentation and an extensive bibliography.

Is such a specification an impossible one in this far from ideal world which engineers inhabit? Herr Franken's book on contactor switchgear fully meets the specification. To a pessimist his book is the exception that proves the rule that such books cannot be written! But whether one is a pessimist or an optimist, here is a book to be accepted with gratitude. Almost 400 pages on contactor technology are probably more than most engineers will want at any particular moment. This is therefore not a book for reading right through. It is essentially a reference work and as such is a joy to use.

The arrangement of the subject matter is logical and the style of writing is lucid. There is a good deal of constructional detail, but there are also excellent sections dealing with the physics of electrical contacts and with various types of switching surges. Control circuits are discussed and throughout the work the author is drawing on extensive experience with installations. The bibliography provides access to relevant articles and papers.

Professor Lesch's *Textbook of High-Voltage Technology* is also a book written by an engineer for engineers. Professor Lesch was, until his death in 1956, at the Technische Hochschule, Karlsruhe, and the book was edited posthumously by his colleague Dr. Baumann. The claims made by this book are more extensive than those made by the book on contactors. It is said that the book is addressed to design engineers as well as to students. It is doubtful if these aims have been achieved and probably they never can be, unless by students are meant postgraduate students.

The book is elementary and largely descriptive without close discussion of fundamentals. It is doubtful if it will tell high-voltage engineers anything they do not know already, but thanks to its many beautiful photographs, it could be used to great advantage as a modern introduction to the subject of high-voltage engineering. As such it can be received with gratitude, and the possessor of the book can safely throw away his collection of publicity leaflets on high-voltage apparatus.

The third of these three books by engineers for engineers is likely to appeal to only 50 or so people in this country, but they will accept it with enthusiasm. Professor Benedikt deals with the solution by graphical methods of problems involving complicated magnetic circuits including highly saturated iron of varying cross-section. Such problems arise in the design of rotating electrical machines and are solved by empirical methods based on experience with previous machines. Benedikt shows how much these methods can be improved by a carefully thought-out technique.

The claim that his technique saves time is not so valid in these days of digital computers. Nevertheless it is extremely valuable in giving a better understanding of such effects as leakage flux and magnetic loss. This is not an easy book to read, but it can be warmly recommended to design engineers who are wondering why their ampere turns are not producing the right amount of flux in the air-gap.

P. HAMMOND

A World of Bosses

The Lincoln Lords. By CAMERON HAWLEY. *Michael Joseph.* (21*s*)

A man walks the streets, out of work.

He is dressed as someone of importance, conservatively impressive. Around him, past him, a rude spring torrent, flows the New York throng, animated by a noon-day vigor. But the man's spirits do not respond to the collective gaiety; inwardly, he is despairing, wretched.

Yet his head is forced high and his legs propel him with a briskness they do not feel towards a destination which does not exist. He is one of those who dare not express his emotions.

This is Lincoln Lord, ex-executive, "temporarily at liberty to consider high-level situations." He is only too aware that he lives among a race of contenders where losers are not tolerated and failure is synonymous with disgrace.

Feeling panic clutching for him, he frantically enters a high-priced automobile showroom. Immediately, a smooth-faced salesman strides out from his office, smiling professionally at the prospect of a big commission. As he approaches, he gauges his man with the practised eye of thousands of such encounters. He hesitates; then stops. He frowns. With a faintly perceptible sneer, he pivots and disappears back into his office, leaving Lincoln Lord to his empty scrutiny of the sports car gleaming before him.

"Damn," Lincoln Lord thinks hopelessley. "It's really as obvious as all that, is it?"

He pushes through the doors, his shoulders now beginning to sag.

In such a manner is the title character of this novel introduced.

The author, Mr. Cameron Hawley, has himself served as a major executive for a large American corporation over many years. He knows this life as only a responsible insider may know it and he is intimate with the fears, hopes and emotions of those who people the large plants and office buildings. He views the scene with eyes which are neither jaundiced nor indulgent. Unlike the myth spinners and social protest writers who, for the sake of money or a political ideal, present the executive as either a spoon-fed darling or an unmitigated villain, Mr. Hawley sees him as the human being he is, possessing all the strengths and foibles which this term implies.

The Lincoln Lords is a protest against the nameless committee rule to which modern big business has married itself. The hero finds his satisfaction and his own soul only when he assumes the leadership of a small but promising canning company, after ten years spent in the committee rooms of the corporate giants amid the schizophrenic ambiguities and sly pressures of "co-operative decision-making." In the smaller enterprise, too, he has his problems, but for the first time his errors and his triumps are solely his own. And here he regains the dignity and faith in himself which had been slowly sapped over the course of the previous decade.

However, this is more than just the story of one man's regeneration. Woven into the sprawling panorama of corporate complexities and intrigues, Mr. Hawley also manages to make statements regarding pure-versus-applied scientific research, family problems, personal morality, anti-semetism and the aloneness of the individual. A grand attempt, surely.

This is the author's third novel since having retired from the trials of the business world.

But his withdrawal has been in name only, his enthusiasm for his subject infiltrating every page of this work. It is evident that he loves the sphere and the people about which he writes, and his art compels the reader to do likewise.

At long last, the executive world has found its novelist. The larger world outside has every reason to be grateful.

DAVID CHAGALL

An Art on Firm Foundations

Reinforced Concrete Piling and Piled Structures. By F. E. WENTWORTH-SHEILDS, W. S. GRAY and H. W. EVANS. *Concrete Publications Ltd., 14 Dartmouth Street, London, SW1.* (18*s*)

During the last quarter of a century the growth of soil mechanics has enabled engineers to bring new methods to the solution of foundation problems. When applied to the behaviour of piles, the new science has found the reason for some of the failures which occurred in the past, and has shown the need for caution in accepting without question some of the piling engineer's most cherished techniques, such as, for example, the calculation of bearing capacity by a "driving formula."

Much of what is written on piling at the present time is concerned with the relation between the bearing capacity of piles and the properties of the soil in which they are placed, and is possibly intended for the soil mechanics engineer with a special interest in piling rather than for the general civil engineer. A reappraisal of the mechanics governing the behaviour of piles is taking place, and there are many points where basic knowledge has been found to be lacking, and some where the scientific approach has raised controversy.

Piled structures have to be built in spite of this uncertainty, and the fact is that practical piling is something of an art, in which accumulated experience counts a great deal, for very often rule of thumb has to be pressed into service where science cannot give the answer.

This state of affairs is hard for the student, who must collect reliable knowledge from somewhere if he is to become a useful engineer, and for the engineer in the small office who is called upon only infrequently to design piling work. To such people Wentworth-Shields and Gray's book *Reinforced Concrete Piling* has been a valuable stand-by for the past twenty years.

For the second edition of this book Mr. H. W. Evans joined the original authors, both of whom have died, Mr. Wentworth-Shields while the book was in preparation. The new edition covers the same ground as the earlier work, but a number of amendments have been made to bring the chapters up to date. The examples of piled structures are more extensive, and this expansion has led to the modification of the title by which the first edition was known.

With the exception of a short chapter on cast *in situ* piles, the subject matter is concerned with precast bearing and sheet piling and their use. The design and production of piles, the investigation of a site, the installation of the piles and the ways of finding their bearing capacity are outlined. The use of piles as units incorporated into a structure is dealt with by examples drawn chiefly from the authors' own field, that of dock and harbour works.

The book is not deep; the authors have presented a little of each aspect of their subject as simply as possible with a minimum of mathematics. The effect in some cases is to pass very lightly over some of the most difficult problems facing the piling engineer, for example, the behaviour of piles in groups, and piles in frictional soils, especially when cast *in situ*, might have been given a little more discussion. The book is essentially directed to the practice of an art; the authors clearly write from their experience, and the beginner could well start by learning from them.

One serious point of criticism must be made. Since the book is an introduction to the subject rather than a comprehensive text, it is a pity that the authors did not include a bibliography for the reader wishing to follow up any of the points so briefly treated. A selected reading list appended to each chapter would extend the horizon without detracting from the handy nature of the book. An index is given.

THOMAS WHITAKER

Nuclear Power Promotes Materials Development

Magnesium and Its Alloys. By C. SHELDON ROBERTS. *Wiley, New York and London.* (72*s*)

Magnesium has for thirty years been a metal of high promise. It combines low density, high thermal conductivity, good ductility, reasonable strength and is readily fabricated, and as such, might be expected to play a prominent part in the aero, and other light-engineering industries.

More recently a further favourable property, low neutron capture cross-section, has carried magnesium into nuclear reactor engineering, and it will, in the foreseeable future, be used as a canning material for a greater weight of uranium than all its rivals combined.

The features, however, which have combined to resist the really large scale use of magnesium in conventional engineering are even more prominent in the nuclear field. In nuclear technology the possible competitors of magnesium have even greater shortcomings. Therefore such properties as ready oxidation, very poor corrosion resistance, anisotropic structure which leads to uneven deformation and low creep strength are obstacles which must be overcome rather than warnings not to venture further. The result is that more has been learned of the manufacture and properties of magnesium in the last ten years than had been known previously. Further, such phenomena as its tendency to form grain boundary cavities under strain have been shown to occur to a similar extent in almost all other metals under equivalent conditions of strain.

Clearly, the employment of this metal in any application requires an up to date knowledge of its properties. Prior to the publication of *Magnesium and its Alloys*, any recent information had to be obtained by a tedious examination of original papers since the last exhaustive treatise was written in 1939. The book is designed to fill the need for a comprehensive account and covers the whole subject with the exception of history, commercial alloys and metallography. In particular, it enters with great detail into the complex deformation behaviour, a knowledge of which is an essential prerequisite for the use of the metal.

The book assumes a metallurgical knowledge of at least honours degree standard, is interesting, well written, well presented and easy to read. There is concise and useful information on a wide range of subjects and the list of references to each chapter seems comprehensive and up to date. As a guide to other follow-up reading it is probably very good.

Although all subjects are dealt with in a confident style the treatment is sometimes a little sketchy, presumably due to lack of space. Some sections of particular interest are generally too short and worthy of a fuller treatment. Here may be the main failing of the book; the very wide scope covered in a comparatively small volume. To range from casting and fabrication to mechanisms of precipitation and deformation and hope to treat any topic very thoroughly needs more space than is available here. One chapter is essentially a collection of equilibrium diagrams which can be found in any appropriate reference book, and this space could possibly have been used to greater benefit in enabling the expanded treatment of some of the other subject matter.

There is a mention in the introduction that controversial subjects have been avoided and that favourite topics may be missing, so to some extent the author has forewarned us that the book does not attempt to deal in detail with everything. It is to be hoped that the next edition will fill in some of the gaps, but the present one is so useful that no one desiring to understand magnesium would be advised to delay in making its acquaintance. The book is well indexed and has a full bibliography including most of the important papers from both sides of the Atlantic.

L. M. WYATT

Electrical Teaching on a Three Point Base

Electromagnetic Field, Energy, and Forces. By ROBERT M. FANO, LAN JEN CHU and RICHARD B. ALDER. *Wiley, New York and London.* (96*s*)

The Electrical Engineering Department at the Massachusetts Institute of Technology has recently been engaged in a process of "new thinking," and this book is one of its products. Many people will be familiar with an earlier development of this kind, in the 1930's, which led to the publication of a series of books, of which Stratton's *Electromagnetic Theory* is one of the best known. But the Second World War and that remarkably vigorous process of self-examination which is now visiting almost every corner of American education, have led to a further review of the syllabus and reassessement of the teaching programme. Now it is asserted that all students of electrical engineering must have a broad basic core of knowledge, rather than a detailed intimate knowledge of present day technology. It will then be left to the industrial concerns into which these students go, at the end of their four-year programme for the equivalent of a British B.Sc. degree, to provide the necessary expert knowledge for each particular type of job.

Such a policy represents a considerable change from olden days. But it is one that will commend itself very warmly to almost all British univer-

sities and responsible leaders in industry. It is important, therefore, to see how this new policy works out in terms of the " course books " specially written for it.

The present book is described as an elementary course. But its starting point is very different from the usual. For it bases its whole account on three principles: (1) the integrated form of Maxwell's equations for the relation between electric and magnetic fields; (2) the force on a moving charge, which can be used, in principle, as a means of defining **E** and **H**; and (3) the introduction of polarisation in dielectric or magnetisable media under the influence of electric or magnetic fields. As a result there is scarcely a mention of the isolated magnetic pole (for this many people will feel a sense of gratitude), and the displacement vector **D** and the magnetic induction **B** appear only as conventient symbols to simplify the writing of equations. There is much to be said for this policy, provided the book is for engineers and not mathematicians, since it facilitates the understanding, but achieves it at the expense of losing the great mathematical simplifying features of a Lagrangian formulation, and also it obscures the significance of the Lorentz transformation of Maxwell's equations.

A further policy, again primarily directed to the electrical engineers, is a reversal of the usual way of dealing with the relation between electric and magnetic fields and the charges or current responsible for them. Older books chiefly ask what fields would result from a given set of charges and currents; but the present book, looking more realistically to the design of electric motors, supposes that the fields are given, and then asks what sources would be required in order to establish these fields. This is an interesting change of outlook, emphasising clearly the real purpose for which the book has been written.

The scope of the book may be gauged from the fact that it begins with an elementary, but clear, account of vectors, then uses the assumed form of Maxwell's equations to deduce Coulomb's law and all the rest of electrostatics and magnetism, but leaves off at the theory of wave propagation and skin effect. By British standards it is a large book for such a syllabus. But there is plenty of evidence of good teaching experience behind the many excellent diagrams, and in some of the exercises at the end of each of the ten chapters.

One particularly interesting technique, which is original in this context (so far as I am aware) is the use of a time-rate parameter to discuss slowly varying fields. This is equivalent to studying how the various field quantities depend upon the time-scale, or frequency. In one of its applications it leads to expressions for **E** and **H** which are given as power series in this time-rate parameter, and are equivalent (in this subject) to certain perturbation expansions commonly used in other branches of applied mathematics and theoretical physics.

Rationalised mks units are used throughout, and the whole account moves in terms of large-scale macroscopic concepts. There is no reference to atomic or microscopic behaviour. Thus all the equations are relative to continuous media. This is adequate for nearly all applications, though there are advanced situations in modern engineering where this will not do.

It is an excellent book, very readable and very well set-up. The chief objection is its price, which puts it right out of the range acceptable to British students. This is a pity, because it is a book that a student ought to have by him, and work steadily through, rather than consult from time to time in a library.

C. A. COULSON

New Books

Chemical Engineering Practice. Edited by HERBERT W. CREMER. Volume 10, Ancillary Services. *Butterworths Scientific Publications.* (100*s*)

The latest volume of Cremer's monumental compilation (to be completed in 12 volumes) is concerned with fuels, combustion systems, steam, electrical installations, water supplies, and effluent treatment and disposal.

An Introductory Treatise on the Lunar Theory. By ERNEST W. BROWN. *Dover Publications, New York; Constable, London.* (16*s*)

Facsimile reprint of the 1896 edition of this American mathematician's contribution to the three-body problem, examining the approaches previously presented by Laplace, de Pontecouland, Hansen, Delaunay, and Hill.

Industrial Electric Furnaces and Appliances. By V. PASCHKIS and JOHN PERSSON. 2nd Edition. *Interscience Publishers, New York and London.* (180*s*)

The two volumes of the first edition have been consolidated into one, making possible a simpler arrangement of material. Thermal and electrical computations and the selection of designs to be treated have all been revised.

Irrigation and Hydraulic Design. By SERGE LELIAVSKY. Volume 3. *Chapman and Hall.* (273*s*)

The last volume of this comprehensive work of reference deals with multi-purpose hydraulic structures, such as the various types of headworks on alluvial rivers, from the standpoints of design, execution and economics.

The Physical Examination of Metals. Edited by BRUCE CHALMERS and A. G. QUARRELL. 2nd Edition. *Edward Arnold.* (168*s*)

Nearly 20 years have passed since the first edition of this book appeared, and the authors have observed a much more ready acceptance of new techniques among metallurgists. Under the circumstances a completely new edition was necessary, presenting accounts of all the principal physical techniques, apart from radiography.

Nuclear Propulsion. Edited by M. W. THRING. *Butterworths.* (50*s*)

A rather random collection of papers on nuclear engineering starting from first principles, with no explanation of the aim of the book, and only 7 out of 16 papers specifically concerned with nuclear propulsion.

Introduction to Quantum Mechanics. By ROBERT H. DICKE and JAMES P. WITTKE. *Addison-Wesley Publishing Company, Reading, Massachusetts, and London.* (66*s*)

An introduction to the physical concepts and mathematical formulations of non-relativistic quantum mechanics, designed as a textbook for courses at graduate level, but also suitable for advanced undergraduates.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Materials

Rubbers. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, 5-11 Regent Street, London, SW1. A useful introduction to what some of the new rubber compounds are being used for. List of makers who are members of the RABRM. 16 pp., ill.

Glass Reinforced Plastic for Boats. TURNER BROTHERS ASBESTOS CO., LTD., Rochdale. Introduction to glass reinforced plastics with emphasis on use of Duraglas reinforcements. 13 pp., ill.

Chromium Plating. MOND NICKEL CO., LTD., Thames House, Millbank, London, SW1. Company will now send up-to-date lists of platers and manufacturers who have joined the scheme to improve chromium plating (by improving nickel undercoats). 10 pp., unill.

Zirconium. IMPERIAL CHEMICAL INDUSTRIES LTD., PO Box 216, Birmingham 6. Properties of company's wrought zirconium and its alloys with applications. 16 pp., ill.

Titanium. IMPERIAL CHEMICAL INDUSTRIES LTD., PO Box 216, Birmingham 6. Corrosion resistance of titanium in a large number of industrial chemicals. 16 pp., unill.

Copper and Alloys. IMPERIAL CHEMICAL INDUSTRIES LTD., PO Box 216, Birmingham 6. Properties, forms and applications of company's copper and copper alloy rods and sections. 47 pp., ill.

Aluminium Extrusions. IMPERIAL ALUMINIUM CO. LTD., PO Box 216, Birmingham 6. Four more booklets from this company. First a general one on extruded and drawn sections with details of alloys. 10 pp., ill. Second on Mark III lorry body sections. 28 pp., ill. Third a catalogue of extrusions; volume 1, standard sections. 130 pp., ill. Fourth the second volume of the foregoing catalogue of extrusions, selected sections. 38 pp., ill.

Electrical Contacts. JOHNSON MATTHEY AND CO. LTD., 73 Hatton Garden, London, EC1. Materials, forms and properties of electrical contacts made by company. 30 pp., ill.

Platinum Metals. ENGELHARD INDUSTRIES LTD., 52 High Holborn, London, WC1. An introduction to industrial uses of platinum metals. 14 pp., ill.

Free-Turning Copper. IMPERIAL CHEMICAL INDUSTRIES, LTD., PO Box 216, Birmingham 6. Kutern is an alloy of copper with tellurium. Machinability is " 90 per cent that of free-turning brass." 2 pp., ill.

Engines and Pumps

Transport Diesels. NORRIS, HENTY AND GARDNERS LTD., Barton Hall Engine Works, Patricroft, nr. Manchester. Publication 747 describes the firm's complete range of diesel engines from 35 to 204 hp 4 pp., ill.

Fuel Injection. C.A.V. LTD., Acton, London, W3. Fuel injection equipment, pumps, filters and nozzles, described in detail with cut-away drawings and sections. Brochure, 36 pp., ill.

Steam Turbines. DE LAVAL LJUNGSTROM (GREAT BRITAIN) LTD., 129 Kingsway, London, WC2. Brochure describes the recent trends in the development of the Stal turbine with coloured section drawings. 10 pp., ill. in four colours.

Feed Pump. RHODES, BRYDON AND YOUATT LTD., Stockport, Cheshire. The SC range of Mopump boiler feed pumps has models with differential delivery pressures up to 250 lb per sq. in. Described with sectional drawings in brochure. 10 pp., ill.

Centrifugal Pumps. GOODENOUGH PUMPS LTD., 112 Jermyn Street, London, SW1. Portable self-priming centrifugal pumps driven by petrol or diesel engines or electric motors. Sizes from 1 in to 6 in. Leaflets, ill.

Fire Pumps. RANSOMES AND RAPIER LTD., Waterside Works, Ipswich. Self-priming water pumps, 3 in connections. Output with ½ in nozzle at 60 lb per sq. in, 48 gallons per minute; with ¾ in nozzles, 108 gpm. Leaflet, ill.

Double-Volute Pumps. DAVID BROWN CORPORATION (SALES) LTD., Penistone, nr. Sheffield. This company are now making Bingham double-volute pumps. Leaflet, ill. with drawings.

Self-Priming Pumps. FIRTH CLEVELAND PUMPS LTD., Markfield, Leicester. Lightweight self-priming portable centrifugal pumps with choice of power units. Sizes 1 in to 3 in. Various leaflets, ill.

The Reviewers

Mr. P. Hammond, M.A., M.I.E.E., A.M.I.Mech.E., is lecturer in engineering at the University of Cambridge.

Mr. David Chagall, himself a novelist, is now employed on editorial work at the Institution of Electrical Engineers. His first novel, *Diary of a Deaf-Mute*, published in Sweden last spring, bears the endorsement of Albert Camus, recognised until his death last year as one of the world's greatest writers and philosophers. Mr. Chagall, who is a nephew of Chagall, the painter, is a B.A. in psychology and physics of the Pennsylvania State University and *liscence* in literature of the Sorbonne. He was formerly employed in the advertising department of a large American pharmaceutical corporation.

Mr. Thomas Whitaker, M.Sc., A.M.I.C.E., A.M.I.Mun.E., is principal scientific officer at the Building Research Station of the DSIR.

Mr. L. M. Wyatt, M.A., F.I.M., is chief metallurgist of the Central Electricity Generating Board.

Professor C. A. Coulson, F.R.S., is Rowse Ball Professor of Mathematics at Oxford University, and is on the staff of the Mathematical Institute. He is a fellow of the Institute of Physics and author of a popular small book on electricity, covering somewhat similar ground to that of the book under review.

Marketing

Propulsion Machinery for New Cable Ship

ENGLISH ELECTRIC have won the £300,000 order for 6,000 shp twin-screw diesel-electric propulsion equipment for the new cable laying ship to be built by CAMMELL LAIRD at Birkenhead for CABLE AND WIRELESS.

The propulsion machinery will be the most powerful ever used in a British built cable layer. The installation will be made up of four eight-cylinder main engines driving direct current generators in series with the two 3,000 shp 800 volt 146 rpm main motors.

The machinery is to be controlled on the modified Ward Leonard principle from the bridge and a number of other stations. Two 500 kW generators, tandem driven from the main generators, and two 500 kW auxiliary diesel-driven generators, will supply the auxiliary power.

The four main engines are to be made at the English Electric Rugby works, the auxiliary engines at the Vulcan foundry, Newton-le-Willows, the auxiliary machines at Bradford, and the heavy electrical machines and control gear at Stafford.

ACV take over Thornycroft Subsidiary

ASSOCIATED COMMERCIAL VEHICLES have bought all the share capital of TRANSPORT EQUIPMENT (THORNYCROFT), the wholly owned subsidiary of John I. Thornycroft made up of all the Thornycroft road transport and automotive diesel engine manufacturing and selling interests.

Within the ACV group, Transport Equipment (Thornycroft) will continue to produce, market and service their specialist commercial vehicles. The company's surplus production capacity is to be used by AEC, the chief subsidiary of ASSOCIATED COMMERCIAL VEHICLES, to meet the rising demand for their own range of products.

The purchase price was agreed as 150,000 fully paid £1 ordinary ACV shares ranking with the present ACV ordinary share capital, and £1,000,000 to be paid in cash over two years, subject to adjustments to allow for trading before the take-over.

Preparing the Soviet London Trade Fair

Twelve thousand exhibits are to be brought to London for the SOVIET TRADE AND INDUSTRY exhibition to be held at Earls Court between 7 and 29 July this year. Spread over 270,000 sq. ft—the ground floor and a sizeable part of the first—the exhibition will take in Soviet industry and technical research, cultural affairs in the form of books, fashion shows and education, and developments in power generation and transmission.

Displays showing the methods used in housing construction and in industrial building will be used to show, in the words of Mr. Michael Nesterov, president of the USSR CHAMBER OF COMMERCE, at a recent conference in London, how the enormous scale of building development now going on in the Soviet Union is made possible.

Behind all the activity of the Soviet exhibition in London and the United Kingdom show in Moscow, there is a background of steadily rising Anglo-Soviet trade. The stimulus provided by the five-year agreement signed in May, 1959, led to an increase in the two-way trade of 17·5 per cent in 1959 compared with 1958. The provisional figures for 1960 show this rise to have been continuing.

The traditional Russian exports to Britain—sawn timber, plywood, cellulose, manganese ore, asbestos and certain food and fodder grains—continue but, in addition, the Soviet trading bodies would like to send to Britain their engineering products, including tools, and of course oil and petroleum products.

After culture and the agricultural sections, the largest divisions of the exhibition will be those devoted to atomic energy and to building. Relatively small in the space allocated (4,300 sq. ft) the outer space exhibit with its models of sputniks and of the instruments carried in them will be certain to attract a great deal of attention.

Among the machine tool exhibits brought to Earls Court will be programme controlled equipment, accompanied by demonstrators and executives able to talk about methods of manufacture, prices and delivery dates. The machinery and machine tool section will occupy almost 9,000 sq. ft. Approaching 11,000 sq. ft has been set aside for the aviation exhibits.

Altogether 300 Soviet executives and demonstrators will be travelling to London for the three week exhibition.

In the other direction, some weeks earlier, the number of British businessmen and exhibition staff who will be going to Moscow for the British Trade Fair has now risen to 2,000. The determination on both sides is that these exhibitions shall not simply be exercises in showing the respective British and Russian flags, but tough, no-nonsense efforts to sell a greater range of manufactured products in larger volume than has so far been attempted.

Mr. Nesterov observed on this point, that the proportion of their overseas trade which passes between the United Kingdom and the USSR is still very small indeed.

Farm Incomes Sensitive to Machinery Costs

The intensive mechanisation of the United Kingdom's agricultural industry since the Second World War is a much laboured theme. All the more surprising for that reason is the statement at the recent National Power Farming Conference that labour costs on British farms today average 25 per cent of the total costs, compared with 26 per cent before the Second World War. This more or less steady proportion has obtained despite a 12 per cent fall in the numbers working on the land and is presumably a reflection of raised agricultural wages.

The figure was given by Mr. J. Howard Morgan, general manager of the AGRICULTURAL CREDIT CORPORATION. He explained that the cost of mechanisation had now risen, over the same years, from 9 per cent to 18 per cent. Spending on mechanisation in 1961 is expected to be around £220 million. In spending on this scale even small percentage savings make very big differences. Bringing mechanisation costs down on a dairy farm from 17 to 15 per cent could lift the net farm income by 16 per cent.

New Shipyard Orders for the Clyde

Orders worth well over £2 million have been placed with Clydeside shipyards by P & O—the PENINSULAR AND ORIENTAL STEAM NAVIGATION group. Three 15 knot ships, all of 13,400 tons, are to be built for the group's tramp fleet.

At a time when the total order book for British shipbuilders has been declining for many months, the three P & O ships bring a welcome prospect of continued work at the yards.

Two of the new vessels are to be constructed by CHARLES CONNELL of Scotstoun. The third will be built by WILLIAM HAMILTON of Port Glasgow. Delivery of two of the cargo carriers will be in 1962 and of the third a little later.

BARCLAY CURLE and DAVID ROWAN, two more Clyde companies, will build Sulzer diesel engines for all three ships under licence from the Swiss firm.

Rising Exports and a Five Day Week at Vauxhalls

VAUXHALL MOTORS are well to the front in the revival of activity in the vehicle manufacturing industry. From Luton comes a Vauxhall statement that the January exports of Bedford trucks and bus chassis were a record. 5,113 trucks and bus chassis were sold to over 100 countries—a 15 per cent increase on the previous highest level, established in November of last year. The principal buyers were in India, Australia, Argentina, Denmark, Belgium, New Zealand, Pakistan, Ghana and Finland.

On the car side full five day a week working is being resumed at Luton. For some months a four day week has been worked in the car and light van sections. The company is now meeting increasing car and light van demand in the home market and abroad, particularly in Canada.

From a December level of 8,500 men on a four day week, the numbers on short time have been progressively reduced until at the time of the decision to go back to a full working week the number was down to 4,000.

Lively Car Activity in Australian Market

A good example of the sound trading conditions in the Australian motor market is the report from AUSTRALIAN MOTOR INDUSTRIES Limited, who assemble Standard, Triumph and Mercedes vehicles, that their sales turnover increased by £A4 million, to £A21,700,000, during 1960.

Last last year the first batch of Australian made Falcons, from the FORD MOTOR Company's plant, were exported to Thailand. Orders for Fords had also been received from Fiji and New Guinea. Export investigations are currently being carried on in South Africa, a useful market to the United Kingdom manufacturers and one on which limitations have been placed by the South African authorities for balance of payments reasons, and in South East Asia.

ROOTES (AUSTRALIA) Limited have found demand for vehicles well sustained despite some unsettled conditions in the market.

A round up of the prospects issued from Australia House, London, says that BRYSON INDUSTRIES Limited, of Melbourne, who distribute Jaguar cars, are now receiving substantial shipments.

Leyland into 1961 with a Good Start

LEYLAND MOTORS, the Lancashire heavy vehicle makers who include the STANDARD TRIUMPH INTERNATIONAL car firm among their interests, have already logged definite bus orders worth more than £750,000 in the first few weeks of the year.

SOUTHDOWN MOTORS, who operate between London and the South Coast, have placed a £230,000 order. This covers 40 Leyland Titan double deckers, 20 Leyland underfloor engined Leopard coaches, 10 Leyland Tiger Cub single deck buses and 10 Tiger Cub coaches.

Some 600 automotive and industrial diesel engines in the 95 to 150 hp range have been ordered from the industrial units division. Among the companies placing these orders have been Aveling Barford, Broom and Wade, British Northrop, Yale and Town Manufacturing and Consolidated Penumatic Tool.

A New Firm for Design and Marketing

BUTTERS BROTHERS and Company, the Glasgow specialists in cargo handling cranes, have formed a joint company with HERBERT MORRIS Limited, of Loughborough, for the development, design and marketing of engineering equipment with which both parent firms are concerned.

The new company—MORRIS AND BUTTERS—is to operate from the Hillingdon, Middlesex, office of Butters Brothers. The chairman will be Mr. Benjamin Butters, a Butters Brothers director. Mr. A. Sykes, formerly of the consulting engineers RENDEL, PALMER AND TRITTON, is managing director.

United Kingdom is Spain's Best Customer

Some effect from the liberalising trade measures and the stabilisation carried out by the Spanish Government when, in 1959, Spain became a full member of the OEEC, can now be seen in the 1960 Anglo-Spanish trade figures.

British exports to Spain rose more than £5 million above the 1959 level to a total for the year of £30,500,000. In the reverse direction Spanish exports to Britain rose by 36 per cent—from £51 million to almost £70 million.

These figures were given in Madrid recently by the British ambassador, Sir George Labouchere, speaking to a lunch given for the Federation of British Industries trade delegation to Spain, led by Sir William McFadzean.

It appears from detailed results in the first half of last year that the United Kingdom continued to be Spain's best customer. Because of this there is some reason to hope that British exports to Spain will increase, perhaps at a rather better pace.

Electrochemical Machining

A new metal removal technique based on the use of electrolysis has been developed. The process might well replace conventional metal cutting processes in a wide range of applications.

ELECTROCHEMICAL machining was demonstrated in this country for the first time last month. A rough forged turbine blade in Nimonic 105 with a working surface measuring approximately 2 in by $\frac{3}{4}$ in was machined to finished size, $\pm$ 0·001 in, from being 0·035 in oversize on both faces in a matter of about 5 min. The surface of the finished blade was highly polished, and the machine that did this will cost about £4,500.

The process was developed at the Battelle Memorial Institute of Columbus, Ohio, through research sponsored by the Steel Improvement Forge Company of Cleveland, Ohio. It is available in the United Kingdom through Metachemical Processes Limited of Crawley.

Basic Principles

Metal is removed in this process by passing a direct electrical current between a workpiece anode through an electrolyte to a cathode tool. This current removes electrons from the work piece, converting the surface atoms into positively charged ions which dissolve into the electrolyte.

In practice, the electrodes are brought close together and in this condition the current density over the faces of the electrodes is highest where the electrodes are nearest together and where current density is highest metal removal rate is highest. In addition, electrolyte is pumped between the inter-electrode gap at high speed. This prevents deposition of material on the cathode. Thus, it can be seen that outside shape of the anode can be brought to the same shape as the cathode.

The rate of metal removal can be worked out from Faraday's laws of electrolysis which say that the mass of metal removed from the anode in electrolysis is equal to the product of the current passed, the time taken, and the electrochemical equivalent of the anode material.

In fact, with a static electrolyte, the current density is limited to about 2 or 3 A per sq. in and thus the metal removal rate is very limited. This is so because the solution has to supply the reactants to carry away the ionised metal at the rate it is being dislodged and 2 or 3 A represents the highest current density that a static electrolyte can deal with. In order to make this a practical process a metal removal rate corresponding to 200 to 500 times this limiting current density has to be achieved.

The achievement of this higher rate of current flow is the main feature of the new technique. A current flow of up to 1,500 A per sq. in is possible when the electrolyte is forced through the inter-electrode gap at high speed. The voltage used is about 5·9 V.

The net effect of all this is that a metal can be converted to any desired shape, at quite a reasonable speed.

Using The Technique

The key to the first applications of this technique is held in the previous sentence. For "a metal" here you could say "any metal," because electrolysis is not limited or affected in the least by the hardness or any other physical property of the material other than its electrochemical equivalent.

Thus, the first applications of the process have been in the machining of the hitherto difficult to machine metals such as Nimonics. In particular, a lot of the initial work has been carried out on turbine blades where great financial savings can be made.

In other applications, a forging die that requires 7 hr or longer to be completed using conventional methods can be finished in 50 min by electrochemical machining. One high temperature alloy that consumes 3 drills and takes 1½ hr to produce has been electrolytically drilled in the same time using only one drill which remains useful for many more jobs.

SIFCO are being quite reasonable when they say that the process is potentially capable of duplicating all of the common metal shaping operations in use today. In addition to this, the process has added a new type of operation which promises designers much greater latitude in the choice of metal shapes which can be made economically.

In practice, one of the problems with this process is the electrolyte. To achieve optimum conditions, a special electrolyte has to be selected

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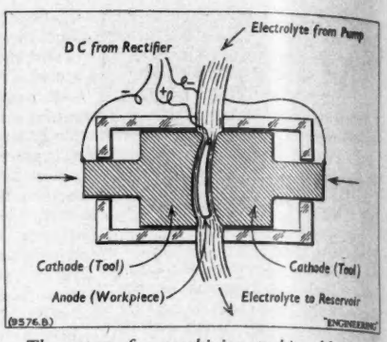
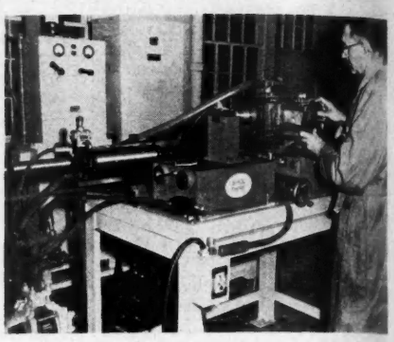


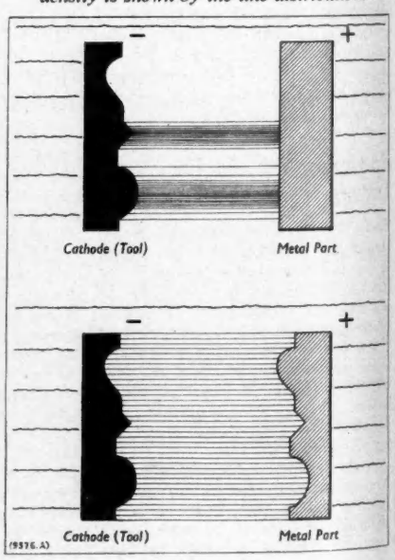
The set-up for machining turbine blades.

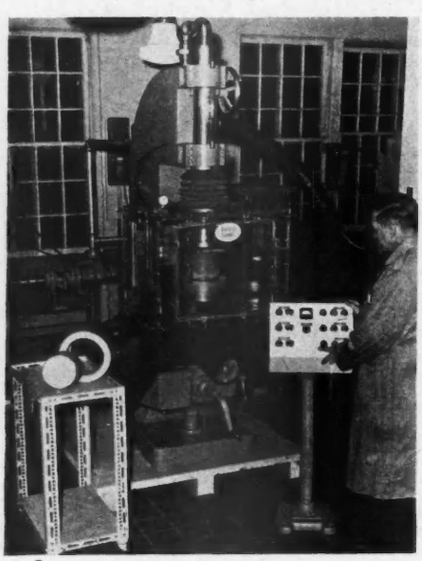


Finishing rough forged turbine blades in a machine similar to that demonstrated in this country.

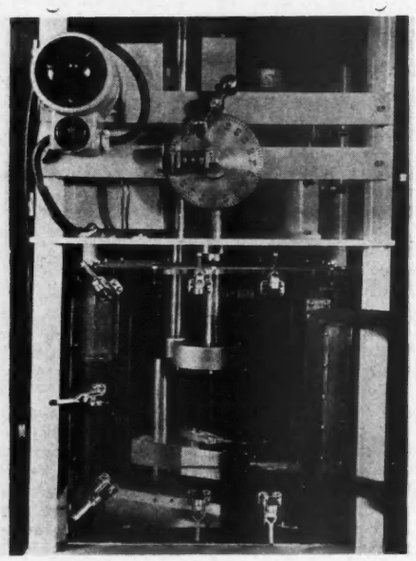
(*Above*) *Cutting up tungsten rod.*

(*Below*) *The diagram shows electrodes before (above) and after machining (below). The current density is shown by the line distribution.*





Electrochemical trepanning. A 7 in diameter core is being removed from a 10 in diameter by 4½ in deep block of tungsten.

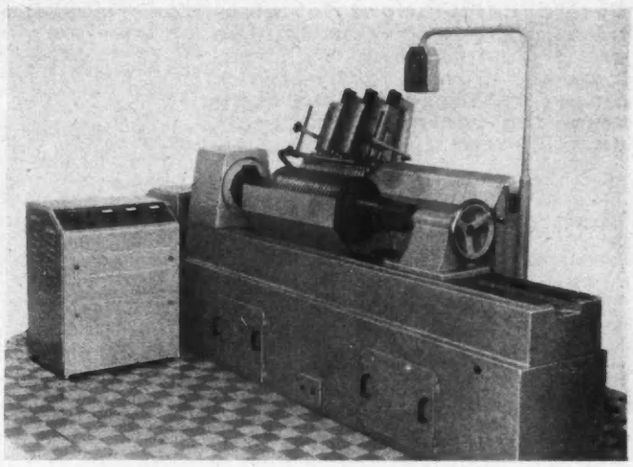


Electrochemical drilling. Straight holes down to diameters of 0·012 in can be produced. The electrolyte is forced down the centre of the "drill."

Profiling Grooves by Electro-Erosion

A wide range of electro-erosive production machinery is under development at the Výskumný Ustav Mechanizácie A Automatizácie, Nové Mesto, Nad Vahom, Czechoslovakia—electro-erosive wire saws, band saws, disc saws, drilling machines, die sinking machines, threading machines, strain hardeners, and scribers. One of the items developed and at present in production is the IJV-4 semi-automatic machine for profiling grooves on rollers used to produce reinforcing bars for concrete. It can handle rollers up to 5·8 ft long and 1·07 ft diameter, and machines the required pattern of groove along the whole length of the roller, according to the programme set up in the control cabinet. The equipment has the advantage that only a very simple tool is used, namely a sheet iron electrode. The working fluid is water, and the working speed is independent of the hardness of the rollers.

Three working heads are used to impart a vibrating motion to the electrodes and to bring them into operation at predetermined time intervals. The time necessary for machining one row of grooves is set up on a time relay; after this time has elapsed the electrode holders lift and step into a new position. When the machining has been finished the machine stops and signals completion, by a light on the control panel.



Rollers for producing reinforcing bars for concrete are profiled with a simple iron tool.

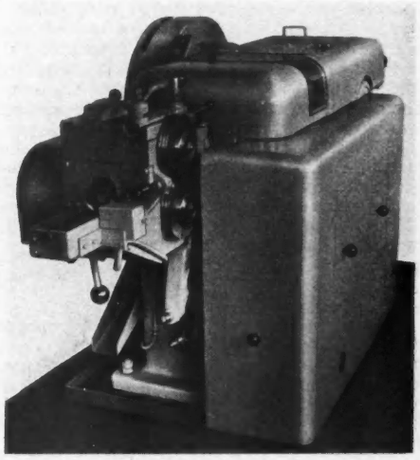
Up to 30 working electrodes can be used, operating at 23 V. The speed of the machine is quoted by Strojimport to be, at 30 A per head, about 60 grooves per hour for reinforcing bars 0·4 in in diameter; consumption of the working electrode amounts to one piece per pass. To obtain a smoother finish a current of about 10 A can be used. The dc power derives from a selenium rectifier circuit and a three-phase transformer, a total of 5 kVA being required.

Screw-Making Press with High Utilisation

Czechoslovak bolt factories are being re-equipped with a new range of automatic double-acting presses, known as type THD, developed at the Šmeral Works, Brno. Their main features are a high rate of output and an ability to produce bolts with a wide range of shapes and length-diameter ratios. The highest effectiveness in the application of the presses has been achieved with special component parts formed by extrusion, such as hollow rivets for motor-driven chain saws. After a minor adaption, it has been possible to attain production of up to 20,000 rivets per shift, which is three to four times as high as the possible output of a normal press with hand feeding equipment, and 16 to 40 times higher than the output achieved with automatic lathes.

The presses produce the shanks of precision screws or rivets by two cold upsetting operations on drawn, annealed, and pickled wire of circular cross section. During the first stroke of the ram, the head is partly upset and the shank reduced in cross-section. In the second stroke the head is completed and the moulding ejected from the die. The type THD6 shown in the illustration is rated at a maximum of 300 ram strokes per minute and can handle stock with a diameter between 3 and 0·24 in and lengths up to 3·4 in. It is powered by a 4·2 kW electric motor.

Careful kinematic design, reduction of the weight of the ram and connecting rod by half, and balancing of crankshaft and connecting rod have led to considerably lower accelerations in key parts of the machine, giving impactless operation even at highest speed and at the full extent of mechanism adjustment. This has led to very high utilisation of the machine in production: time losses per shift have amounted to only 10 to 15 per cent, including the time required for changing the material, adjustment for a different bolt length, and a break of 30 minutes per shift—together with all the usual causes of time losses.



Careful kinematic design and ease of adjustment have yielded a cold-forming press of high productivity.

Concluding

Electrochemical Machining

for each material. However, compositions have been worked out and tried for a wide range of pure metals and alloys including tungsten, molybdenum, titanium, Waspalloy, Nimonic, and a wide range of steels. The electrolyte is not cheap. The cost for the operation quoted in the opening paragraph of this article is 1*s*. It is not expensive either, when one considers the low cost of the machine and the high cost of alternative processes. The life of the electrolyte used in machining turbine blades is about 8 hr but it cannot be long before plating-out-units are incorporated in the machines when they are used on pure metals, though such a unit would seem to be impractical for the more complex alloys.

The turbine blade application of this process is shown in one of the illustrations, where it can be seen how the metal workpiece is held in a specially designed fixture. When this machine was demonstrated, the cathodes which duplicate the final contours to the blade were positioned on either side of the blade at a distance of 0·01 in from it, and a current of about 160 A at 5·9 V was passed. The cathodes were brought in as metal was dissolved away—the gap remaining constant. The electrolyte was pushed through this gap at about 100 ft per sec. When the finished blade was removed from the machine it was coated with a black oxide film, but this was soon washed off to reveal the highly polished blade.

The latest application of the technique is the drilling of fine holes down to diameters of 0·012 in. In this case, the electrolyte is pumped down a fine capillary tube which is coated with insulating material on the outside. It is possible to keep these holes very straight. This is thought to be due partly to a cone which builds up in the parent material at the bottom of the hole as it is being drilled. Turbine blade die impressions have also been sunk down to a depth of 0·56 in since this process was first announced to the public in the USA last autumn.

Buying A Machine

In this country, machines supplied by Metachemicals will be purpose built for the user. They will come supplied with one set of cathodes and type tested for a particular job. Metachemicals are selling the machines subject to two conditions, in order to protect themselves and the good name of the process. The first of these is that the machine must be run under physical conditions which are the optimum. The second condition comes into operation when the machine comes to work on a different job, a time when either cathodes or electrolyte or both must be changed. This change requires the technical knowledge of an electrochemist, and Metachemicals want to supply this knowledge in the event of the user's not having it. Neither of these conditions should deter anyone from using these machines.

Analogue Devices for Network Analysis

Design calculations for electrical power networks can be greatly simplified by analogues. Known as network analysers, these devices combine the work of research, development and design.

By P. G. Kendall, B.Sc.(Eng.), A.M.I.E.E., and P. G. Parrot, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E.

Electrical Research Association

ANY large electrical power system represents not only a striking achievement of modern engineering, but also a large capital investment. If an effective but not extravagant result is to be obtained, great care must be taken to optimise the design of the system. Many complex calculations are involved in such an exercise and one of the best ways of tackling them is with an analogue model. The two main types of model in current use are the dc network analyser and the ac network analyser.

Fault Studies

One of the essentials of power system network design is that circuit breakers should be able to handle not only the normal load but also the heavy currents that flow when faults occur.

If it were not for the complexity of the interconnected network, there would be no difficulty in calculating the fault currents manually. However, when the network comprises more than a very few meshes, the amount of computation required to determine the various currents becomes very formidable. One of the earliest types of network analyser made to solve this type of problem was the dc analyser. In this device, which is still widely used, all network elements are represented by pure resistances, whose value is preset or adjusted to represent the impedance of particular parts of the network.

Fault currents can thus be found by energising the network with a direct voltage and measuring the currents which flow when faults are applied at the various busbars.

The use of pure resistances for forming the network, however, does not permit direct representation of the differences of emf and phase which exist between the various generators under normal operating conditions; nor does it permit a direct representation of the different phase angles of different lines and loads.

Power Flow Studies

Though various methods have been proposed for extending the use of dc network analysers to the study of power flow in ac systems, much the most convenient and satisfactory way of approaching this problem is to build a network analyser which incorporates reactive elements and which can be energised by ac sources.

The design of an ac network analyser is considerably simplified if its operation is restricted to a single frequency. This frequency then represents (but is not equal to) the operating frequency of the power system.

Considerable ingenuity has been exercised in the design of ac network analysers, but the most usual and straightforward arrangement is to represent the resistance, inductance and capacitance of the power system directly by scaled values of resistance, inductance and capacitance on the network analyser. If the network is then energised at the busbars that represent the generating stations by sources adjustable in voltage and phase angle, a direct model is presented of the flow of active and reactive power in the power system.

It will be readily appreciated that the basic purpose of a power flow study is to ensure that the transmission and transformer facilities which have been or will be provided will convey power from generating stations to loads without overload. However, the need for maintaining voltage during heavy load is equally important, particularly under line outage conditions, and the suitable positioning of over-excited synchronous condensers to assist with this is often part of an analyser to power flow problem. Conversely, voltages times of light load must be held down within reasonable limits, and placing of shunt reactors or synchronous condensers, this time under-excited, is often considered. Further, control of power flow by quadrature boosters or series capacitors may be investigated.

Many alternative arrangements of this type can be studied on a network analyser and the best final arrangement determined.

Transient Stability Studies

A single-frequency analyser may be used without modification for investigating transient phenomena whose duration is very long compared with one cycle of the system frequency.

The most important problem of this type is that of the oscillation of the rotors of the generators on a system following a major disturbance, such as that caused by a fault.

Such problems may readily be investigated by a step-by-step study in which the angles of the generators are set to represent their values at successive small instants in time after the fault.

These studies necessitate a certain amount of manual computation between each step and, if the number of generators is at all large, they become extremely tedious and time-consuming. For this reason some network analysers have been equipped with apparatus which simulates the transient behaviour of the generator in this respect, and enables the results to be obtained much more quickly. For such work, one simulator must be available for every generating point which is to be represented on the system.

It is possible to use a single-frequency ac network analyser to investigate the propagation of harmonic currents and voltages in power systems since each harmonic may be represented in turn. For this purpose, however, all the reactive elements of the network must be reset to represent their value at the particular harmonic frequency being investigated and, apart from any limitation on the setting range of the various elements, there is also the danger of setting one or more erroneous values every time the settings are altered. This trouble can be avoided by the use of a variable frequency supply to the analyser network, but such a use is only possible if the network elements and their connecting leads have been so designed as not to have excessive strays at any of the frequencies which are to be used. This necessarily complicates the design of the network analyser but brings a valuable extension of its field of application. Using such a network analyser, it is not only possible to investigate the behaviour of networks at a few different special frequencies, as is done for harmonic studies, but frequency response may also be readily plotted. Suited adjustment of frequency enables maximum and minimum values of impedance to be found in a way which would not be possible if all the reactive elements had to be changed.

ERA Analyser

Though the more usual range of power system studies may be made on single-frequency network analysers, other studies, e.g. of harmonics, frequency response and transient response are sufficiently numerous and important, especially in research and development, to justify a large multi-frequency network analyser.

To assist the industry in the solution of such problems, the Electrical Research Association designed and built a network analyser which is particularly suitable for the study of a very wide range of network problems, including those of frequency and transient response.

The Electrical Research Association analyser (called ENA) follows the well-established principle of representing each element of the electrical circuit by a unit of similar electrical characteristics, but it incorporates several important features which make it suitable for an unusually wide range of problems.

The most outstanding feature is that the operating frequency is immediately and continuously adjustable over a range of 100: 1. This enables frequency responses to be plotted and resonances located much more easily than with any other analyser. Furthermore, the transient response of the network to switching operations or to the sudden application of voltages or currents can be studied without step-by-step methods.

Not only can a wide range of measurements be made, but very extensive networks can be represented by ENA's 18 generators and more than 400 network units.

The equipment has been designed with a special regard for accuracy. All component values have a tolerance of ± 1 per cent. Connecting and measuring leads introduce errors of less than 0·1 per cent of the base quantity.

Steady-state measurements are made by servo-balanced a.c. bridges which give a clear and direct indication of all the measured quantities. This measuring system has a resolution of 0·1 per cent of the base quantity.

Restriking Voltage

The interruption of fault current by circuit breakers in inductive networks is accompanied by large transient voltages across the circuit breaker contacts. These are called restriking voltages and a knowledge of them is required for circuit breaker design and specification. A number of problems involving restriking voltage have been studied on ENA since its inception. These studies may be made by injecting current into the circuit at the point where the circuit breaker is connected and displaying the resulting voltage transient on an oscilloscope. It is not often that the restriking voltage transients of complex networks can be compared with results from a network analyser, but recently several analyser records have been compared with test records, with good agreement.

Cross-Channel Cable

The design of the cross-Channel cable link provides an example of the investigation of both harmonics and transient phenomena in a power system. The rectifier-inverter sets are much larger in rating than those of most rectifier installations, and the suppression of harmonic voltages required special investigation.

The study involved: (*a*) the measurement of frequency response of the harmonic filters; (*b*) a survey of the harmonic voltages throughout the network for different filter connections; and (*c*) a study of transient over-voltages on the filter capacitors resulting from switching or nearby faults.

Such a study illustrates well the particular value of a large multi-frequency analyser.

Originally the network analyser was unchallenged for all but the simplest network calculations, but large digital computers are now beginning to offer an alternative method of solution. Most attention is being given to obtaining digital solutions to problems of fault currents, power flow and transient stability, and it seems likely that, in time, the computer will become the first choice for their solution. Even for these problems, however, the network analyser will continue to be extremely valuable in the early stages of system design.

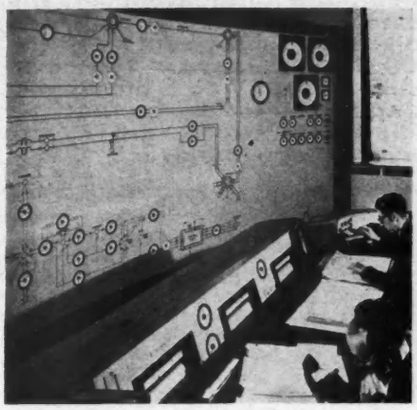
Nation-Wide Control for Electrical Power Networks

An old country house in Hertfordshire has recently become one of the most up-to-date control and communication networks in the United Kingdom. From a control room which embodies the latest techniques in panel layout and construction, engineers of the Central Electricity Generating Board maintain a round-the-clock supervision over the supply of electricity in East Anglia, the north home counties, and London north of the Thames. One of the aims of this control scheme is to keep the price of electricity down.

Part of a new national system for grid control, the Thames North Control Centre at Redbourne is one of seven area control centres which, under the supervision of a National Control Centre, now cover the whole of England and Wales. Each centre uses standardised equipment supplied by the same manufacturers in each case. The centres are located at Birmingham, Bristol, East Grinstead, Leeds, Manchester, Newcastle and Redbourne.

At each centre, electronic strip-chart recorders give control engineers a moment-by-moment picture of the situation in their area. Two of the recorders, for total generated output and system frequency, show load changes as they begin to occur.

This helps in maintaining a steady voltage and frequency of output by allowing control engineers to give early instructions to power stations. A third recorder, marked "net area transfer," has a zero near the middle of the scale, and registers the electricity imported from or exported to other areas. The National Control Centre prepares programmes of power transfers in the light of the national situation. In this way the load on power stations can be arranged so that the cheapest generation costs are always maintained.



New control and communication networks have recently been established by the CEGB.

Larger Turbine Generators Predicted

It has been predicted by an engineer of the Westinghouse Electric Corporation, New York, USA, that turbine generators rated at 1,000 megawatts, will be producing power in the United States within the next 15 years. The largest unit in America today is rated at 475 MW. This prediction was made in a paper read to the American Institute of Electrical Engineers.

The paper referred to a technique called "powercasting," which involves the use of computers to simulate detailed operations of a utility in the future. In effect, by programming future requirements into a computer, utility specialists are able to build a model of a full-scale electric system.

In 10 minutes, a high speed digital computer can reproduce 20 years of experience on a mathematical model, the report states. The model determines which units must be run to supply the load. It starts up these units, adds generating capacity and interconnections with other utility systems and builds transmission systems as required.

At the end of 20 years experience, the computer records all decisions made, together with the dates when additions should be made. It calculates the present value of all revenue requirements, total capital needs and production and operating costs.

The study reported to the AIEE included a comparison of a number of feasible expansion patterns for the system. The 1,000 MW pattern proved economically superior to one restricted to 500 MW units over the next 20 years. Its economic superiority was shown to be unchanged by variations in installed plant costs. The study also showed that patterns using units larger than 1,500 MW could be economical if it were not for increasing internal transmission costs with very large units; 1,500 MW units would not be excessively large as far as reserves are concerned. However, the concentration of capacity in one location on some utilities would increase transmission costs enough to offset the economies of the 1,500 MW unit.

The report pointed out that extra-high-voltage transmission had not been studied as a means of reducing these costs, although it is probable that some utilities may find it profitable to use higher voltages in the future. The author of the paper said that his company (Westinghouse) has already developed an 800 MW turbine generator at its Pennsylvania factory.

Developing Long Turbine Exhaust Blades

Much research and testing on long turbine exhaust blades has been carried out in the Fluid Dynamics Laboratory of the English Electric Company at Rugby. Brief mention of such blades is made in an article on page 294 by Mr. R. Ecker of the steam turbine division.

A practical design for the last blade (the last row of the low pressure turbine blades), with a good flow efficiency at all heights, requires an exhaust chamber which is matched to the blades.

Fig. 1 shows the rotating rig in which a scale model of the 36 in blade row is being tested at English Electric, with exhaust chambers of varying proportions and sizes. This rig operates in conjunction with a variable-density tunnel, which enables tests to be made over a wide range of Mach and Reynolds numbers. Selection of blade material can be made only after analysis of various mechanical and manufacturing tests.

Checking vibration characteristics of new long blades by a rotating test on a full-scale prototype bladed wheel is most important where a considerable departure is made from known sizes. Calculation alone is not yet sufficient to provide the necessary assurance of complete reliability. Fig. 2 shows the prototype wheel with 36 in blades in the wheelcase used for these tests.

The incentive to develop new last blades, longer than those used in the past, springs from the fundamental effect these blades have on the construction of the turbine and on its efficiency and economics.

Considering basic construction of the turbine

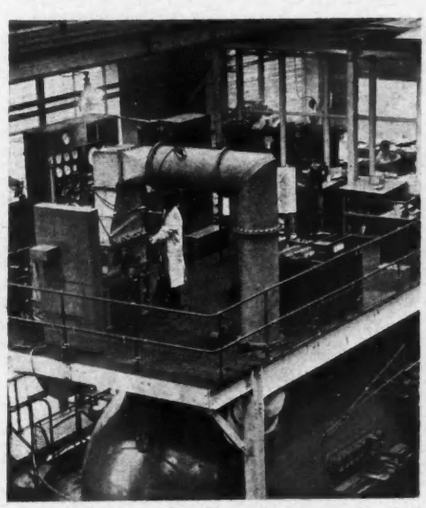


Fig. 1 Rig in which a scale model of the 36 in blade row is being tested.

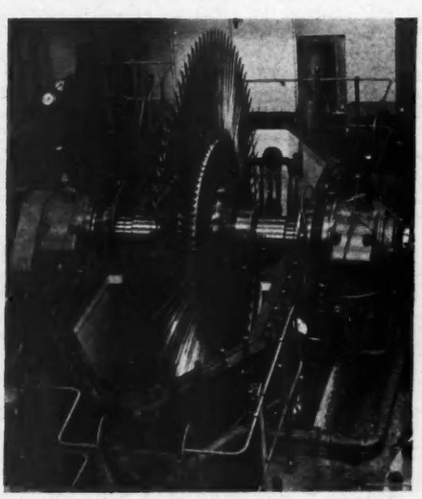


Fig. 2 The prototype wheel with 36 in blades in the wheelcase used for these tests.

frame: if blade developments were arrested at the 22 in blade size, ten low pressure exhausts would be required to give an exhaust loss similar to four 36 in exhausts. Mechanically this would be unattractive.

Considering the economics of a 350 MW turbine unit a reduction in performance by ½ per cent (if, say, 33 in blades were used instead of 36 in) may be evaluated as a loss equal to £175,000 over the life of the set.

USSR Will Have a Unified Power System

Complete unification of the electrical power supply and distribution system of the USSR is planned. Transmission at 800 kV dc is envisaged. Emphasis is to be put on thermal stations rather than hydro-electric power.*

By Professor V. A. Venikov

Moscow Power Institute

THE pre-revolutionary Russia held the first place in the world with regard to size of territory, third place with regard to population after China and India and the fifth place in respect of industrial production after the USA, Germany, Britain and France. Power engineering in pre-revolutionary Russia was a young and little developed field of industry.

In 1913 the total capacity of power stations was 1,200 MW, generation of power was less than 5 per cent of the world electrical output, and in this respect Russia occupied only the 15th place in the world. Power stations were equipped with foreign equipment. The thermal power stations were running on oil and coal transported from far away and the total capacity of all hydroelectric power stations did not exceed 16 MW. The length of all the transmission lines above the generator voltage totalled only about 100 km. The highest voltage used was 70 kV.

In 1920, after the First World War and the revolution, generation of power was only a quarter of that in 1913 and history shows that in those days the generation of power in Moscow, capital of the State, reached a minimum. Only one turbine was in operation and that was fed for a few days from a boiler fired with stocks and other valuable papers from the nationalised banks as there was no other fuel.

GOELRO

The main problem then was that of restoring the economic life of the country on the new basis. The solution called first of all for the development of heavy industry and machine production on the basis of the most advanced technical ground—electric power. The idea was not merely to restore industry as it was in Tsarist Russia, but to recreate it under new conditions with nationalised industry, transport and banks, without private property as a means of production.

This enormous work, on a nation-wide scale, was possible only on the basis of a well thought out single plan of economy. The plan was adopted by the supreme organ of the country—the Congress of Councils—in December, 1920. This was the first all-Soviet plan. Though it was described as a plan for the electrification of RSFSR—abbreviated to GOELRO (State Commission on the Electrification of the Republic)—nevertheless it envisaged not only improvement of power engineering but, on the basis of electric power, enlargement of the whole national economy of the country.

In reality, and in spite of its tremendous scale, the plan was truly scientific in conception and took into consideration both economic and technical possibilities, with the object of fulfilling the following basic principles:

1 Ensuring preferential development of heavy industry, which is the basis of the whole national economy.
2 Ensuring development of electric power engineering for the wide electrification of all sections of the national economy, with a rational distribution of the power facilties in the country, having in mind the fast growth of labour productivity and a radical improvement of labour conditions.
3 Wide utilisation of local sources of fuel and hydro-electric resources, large power stations with the most modern equipment being erected close to power sources.
4 Correlated utilisation of power resources.
5 Uniting of large regional (utility) power stations into zonal electric power systems with a view to organising later a single electric power system for the whole country.

Even now the above principles are not out of date and they were in force for the development of power engineering of the Soviet Union during both the pre-war five-year plans and after the war. These principles are reflected in the seven-year plan and in the future twenty-year plan of development for Soviet power engineering.

ELIMINATING FOREIGN AID

Originally GOELRO was to be fulfilled within 15 years. It envisaged an increase of electric power generation 4·5 times and industrial output by between 1·8 and 2 times by 1935 as compared with 1913. Actually, generation of electric power in 1935 increased by 13·5 times and industrial output by 5·6 times. Thus, all the basic tasks envisaged by the plan of GOELRO were more than completed.

Foreign capital used was a minimum. The entire construction programme was financed by accumulated resources inside the country.

The GOELRO plan was further expanded and consolidated in the five-year plans of national development which were first stated in 1928. These plans were regularly overfulfilled and, by the last pre-war year of 1940, generation of power reached 48·3 million MWh and installed capacity of power stations totalled 11,200 MW.

The war caused great damage to the power systems of the Soviet Union. Over 60 large power stations and more than 10,000 km of high voltage lines were destroyed.

The Germans dismantled 14,000 steam boilers and more than 11,000 generators. Generation of electric power in 1942 dropped to 60 per cent of the 1940 figure.

However, the war did not stop the growth of power engineering. Extension of the power systems in the eastern regions began and, even in the war years, restoration of the destroyed power centres was started intensively. By 1945, generation of electric power in the country had reached approximately 90 per cent of that in 1940, and in 1946 the pre-war level was already surpassed.

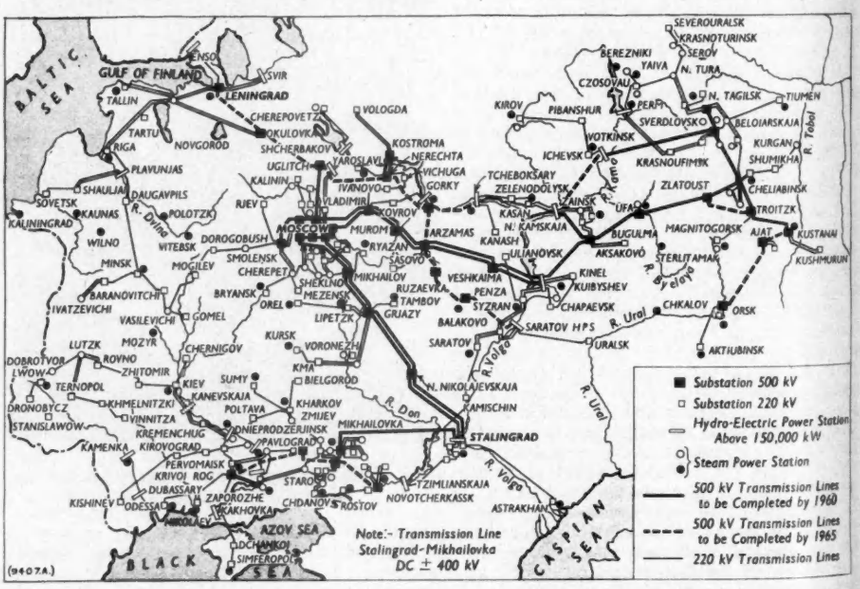
Power engineering in the post-war period is characterised by increases in capacity of the electrical systems, unifying the systems and increasing the length of transmission lines. The maximum capacity and longest single 220 kV transmission line in the Soviet Union by the end of the war were 300 MW and 300 km respectively. The development of the electrical systems and construction of hydro-electric power stations planned in the post-war five-year programmes required immediate ten-fold expansion of transmission. In practice it was necessary to transmit power of more than 1,000 MW to distances of the order of 1,000 km. For this purpose transmission lines at a voltage of 500 kV had to be erected. In addition, alternating current transmission lines are being developed to work at 700 kV and direct current lines to work at 800 kV.

Electricity consumption by agricultural and urban areas began to grow fast. In certain republics the generation of power began to grow faster than industrial output. Inter-republican exchange in electric power was practised and the movements in 1954-55 are shown in the following table.

Inter-Republican Power Exchange (in millions of kWh)

Republic	1954		1955	
	Received	Sent out	Received	Sent out
Russia ..	130·9	1,686·5	328·5	1,273·9
Ukraine ..	1,668·0	4·0	1,242·2	2·0
Lithuania ..	4·1	—	5·6	—
Esthonia ..	—	2·2	11·0	2·2
Azerbaidjan	—	1·3	—	235·0
Georgia ..	1·3	10·5	235·0	6·8
Tadjikian	180·6	1·4	198·9	1·4
Kirgiztan ..	58·4	—	63·8	—
Kasakhstan	13·8	112·8	24·7	117·7

The present seven-year plan provides for even faster development of power engineering. According to this plan, power stations must generate between 500 to 520 million MWh by 1965. The installed capacity of the stations must reach 111 to 113 million kW. Several large hydro-electric power stations, such as Bratsk, Stalin-



The 500 kV transmission system in the European part of the USSR for 1960 and as planned for 1965.

* This article is based on an unpublished address that the author gave to the Engineering Section of the British Association at Cardiff in 1960.

grad, and Kremenchug, and will be completed during the seven-year plan period. The main increase in capacity, however, will be obtained by the construction of thermal power stations which are less expensive in first costs.

Thus, the main trend in electrification of the country will be seen in the preferable establishment of large thermal power stations and approximately five times more thermal stations than hydro-electric power stations will be constructed during the next seven years.

Preference for thermal stations is related to geological findings which have enabled us to find out how rich our country is in fuel. These new discoveries increased the known reserves of fuel and the seven-year plan envisages increases in consumption by 1965 as compared with 1958 as follows: oil by 200 per cent, gas 500 per cent, and coal 120 per cent.

Beyond the seven-year plan annual generating capacity is expected to increase to 2,000 to 2,300 million MWh by 1980.

The most urgent problem which is faced by Soviet power engineering is not merely electrification but *complete* electrification of the whole country so that electricity can reach all the corners of the country.

Hence, the problem of increasing the length of electric lines arises. Construction of more than 200,000 km of transmission lines at a voltage above 110 kV is planned for the period of 1959-1965. A distance of about 100,000 km of lines must be erected for electrification of agriculture.

Complete electrification provides for the subsequent creation of a single power system for the Soviet Union, with all circuits at all voltages being raionalised and different power systems being united. Unified power systems in the European part of the Urals, Siberia and Middle Asia will be created, and then these power systems will be gradually joined together.

The current philosophy of building power systems which are self-sufficient seems to be obsolete because the effectiveness of combining power systems is now recognised even in cases where every system has a power deficit.

IMPROVED MAINTENANCE

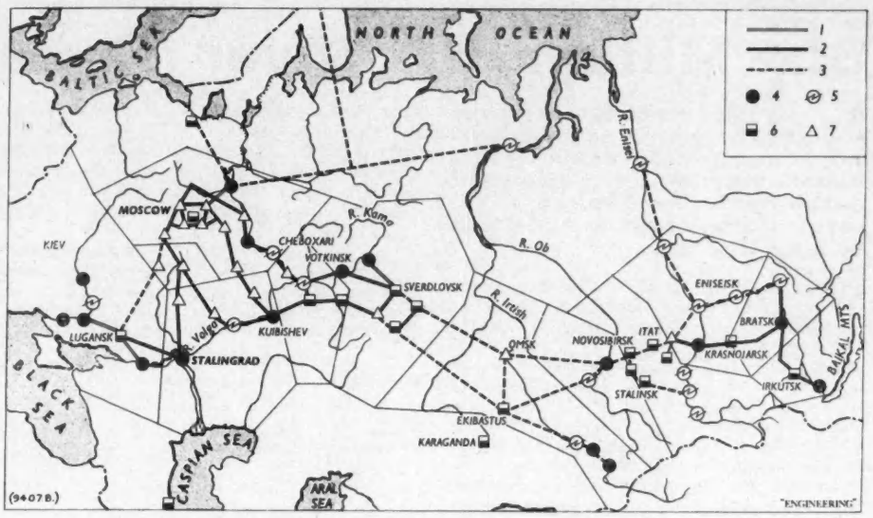
Soviet engineers and scientists have had to solve a great number of scientific and technical problems related to the development of power engineering.

A method of relative increments was proposed in 1927 for determination of the economic distribution of load between parallel operating power stations. Great attention was paid to problems of lightning protection, against inner over-voltages and increase of dependable operation of the power systems. The rapid development of the Soviet power engineering did not always manage to cope with the demand for power by industry and in a number of cases the power systems had to operate with very low reserves or even without reserves at all. The problem of stability of power systems required special attention because of the great distances involved in the transmission of power from the source to the centres of consumption.

Great attention had also to be paid to measures ensuring dependable power supply to consumers. These measures are as follows: routine overhaul, maintenance and tests of equipment; development and introduction of fast-acting relay protection and methods of system automation directed towards increasing stability in parallel operation of power stations; and speeding up the removal of faults.

Automatic field control of synchronous machines has resulted in an improvement in stability and the rapid elimination of emergency conditions in power systems.

Non-stalling of motors of important consumers is of great significance. As a result of dispensing with under-voltage protection and increasing the speed of response of exciters, the dependability of power supply to large enterprises has increased considerably; whereas previously there had been numerous trippings of motors due to short-period reductions of voltage.



Proposed interconnection of power systems in the central region of the USSR.

Legend: (1) Main distribution lines below 400 kV. (2) Transmission lines of 400 kV and above, existing and now being built under the seven year plan. (3) Proposed system connections. (4) Hydro-electric stations existing and being built under the seven year plan. (5) Hydro-electric stations still to be started under the seven year plan. (6) Thermal stations. (7) Substations.

Asynchronous conditions of operation of synchronous machines has become very important. Out-of-step generators, as a rule, are not disconnected from the circuit and re-synchronised.

Mass application of automatic control devices and field forcing, and also the increase of capacity of power systems, allows the influence of short-period asynchronous conditions in a part of the power system in operation to be disregarded. It has been found from investigations that the short-period asynchronous conditions are not dangerous for transformers either.

Automatic reclosing is widely used on the power systems of the USSR. In 1958 almost 80 per cent of all the lines at voltages up to 220 kV were fitted with automatic reclosers. Since 1954 asynchronous automatic reclosing has been used. These devices, which were fitted in transmission lines of 35 kV to 220 kV, were operated 264 times between 1954 and 1956. In approximately 75 per cent of the cases they were successful and there were only two cases when the line had to be disconnected manually.

Automatic reserve closing of the feed sources is widely used in the electric circuits. Successful operation of them is high, between 95 and 96 per cent. Installations for automatic reserve closing are, as a rule, made in such a way that they operate in all cases of disappearance of voltage and at short circuits.

Automatic frequency throwing off is also used. This is very effective and dependable for ensuring operation of the system under emergency conditions. The automatic frequency throwing off operates when the frequency has dropped to between 47 and 48 cycles per second. During 1959 these devices had to be operated very rarely because of the high capacity of the power system, increase of reserves and improved dependability.

TRANSMISSION STABILITY

To increase the capacity and stability of the long-range transmission lines, special measures are used which first consisted of well-known methods such as series capacitance compensation and the use of triplicated conductors to increase the effective conductor diameter. New methods of field control for generators and synchronous condensers are now being employed, including forced (intense) field control for generators by use of the first and the second derivatives of the current and the voltage. This control, being used with high ceilings on exciters, achieves static and dynamic stability and also raises the transmitted capacity of the system to the value of the limiting capacity of the line alone.

At present a number of control methods are being worked out which envisage installation of the forced control not only on the generators operating on long transmission lines but also on generators operating in complex combined systems. In connection with this search for new control methods, other system parameters (for example frequency) can be used.

Investigations have been carried out on the application of electrical and mechanical braking to prevent the hydro-electric generators getting out-of-step. The electric braking is effected by devices responsive to a drop in power output. On the large hydro-electric generators, mechanical braking is effected by hydro-mechanical devices.

Work is in progress on the application of " complex " control to power systems, providing for a simultaneous action upon field control, speed controllers and upon the braking devices where they are installed. This type of complex control always ensures not only a high level of the static and dynamic stability, but also a " resultant stability ", i.e. it can effect automatically the restoration of synchronous operation of generators which have fallen out of step.

UNIVERSITY CONTRIBUTION

Research in power engineering is undertaken by the scientific research institutes of the Academy of Sciences of the USSR and the republics of the Union which, as a rule, have their own power institutes. Much work in this field is conducted by the advanced technical colleges which also have special laboratories.

The contribution of these advanced technical colleges in the general scientific investigations is very great. Over 130,000 professors and teachers conduct investigations. In 1958 scientists at the higher schools completed about 15,000 investigations; in 1959, over 30,000 such investigations were completed.

The technical colleges train the scientific personnel who work not only in the technical colleges but in the research organisations. Over 12,000 post-graduates study at the technical colleges and 4,000 young scientists graduate from them every year.

Persons having a higher education and three years practical experience have the right to work and study in the post-graduate courses. During the three-year period of work in this course, theoretical subjects are studied which increase the knowledge of the post-graduates and each of them prepares a dissertation. After a successful verbal examination, a scientific degree of " Candidate of Technical Sciences " is given to the post-graduate. This is the first of two degrees which can be granted in the Soviet Union.

Six Million HP River Project in Canada

A hydro-electric power scheme, involving several barrages and power stations, has been started in adjacent catchments in Quebec Province. Completion is expected to take 15 years.

WORK has begun on a $2,000 million project to develop the hydroelectric resources of the Manicouagan and Outardes rivers in Quebec Province, Eastern Canada. It is planned to install turbine capacity of more than 6 million horse-power on these two rivers, which lie nearly 500 miles north-east of Montreal. The work will continue over a period of 15 years. The project is rather larger than the Snowy Mountains scheme in Australia.

Access roads have been built to sites for dams and power stations on the Manicouagan, and seismic studies have been carried out at Site 5, located at the river's fifth set of waterfalls, where it is proposed to build a 650 ft high multi-arched concrete dam and power station with an installed turbine capacity of nearly 1·6 million horse-power. It is stated that the dam, 4,000 ft long, will be the largest of its kind in the world. The seismic studies are being conducted to determine the elasticity of the rock at each shoulder of the Manicouagan at this point.

The Manicouagan-Outardes project, which is being undertaken by the provincially owned Quebec Hydroelectric Commission, is the biggest hydro-electric scheme undertaken so far in Canada. Those of the Columbia River and the Peace River in British Columbia are as yet some years from realisation because of economic and political considerations, as is also the Hamilton Falls scheme in Labrador.

Today the total installed capacity in Canada is 24,888,400 hp. From the latest review of installed capacities across the country, it is estimated that the available 66,203,000 hp of water power in Canada will allow a feasible turbine installation of more than 87,000,000 hp, or well over three times the present figure.

SITE DETAILS

The Manicouagan river is to be developed first. The sources of the river are Lakes Manicouagan and Mushlagan lying 250 miles north of Baie Comeau, a newsprint and aluminium centre on the St. Lawrence nearly 400 miles downstream from Montreal. These two large lakes are supplied by several rivers running into them from the north. The Manicouagan, and also the Outardes, flow into the St. Lawrence River just west of Baie Comeau, as can be seen from the map. From the lakes to the St. Lawrence, the Manicouagan drops roughly 1,000 ft.

The drainage area of the Manicouagan is approximately 17,550 square miles and provides excellent conditions for harnessing the river. Present plans call for four major hydro-electric installations on the Manicouagan (Table I):

TABLE I:—*Power Schemes on the Manicouagan*

Manicouagan Power Company installation at Baie Comeau, now partly built with turbine potential of 280,000 hp, would be expanded to a capacity of	580,000 hp
Manicouagan 2 (Quebec Hydro)	1,100,000 hp
Manicouagan 3 (Quebec Hydro)	1,050,000 hp
Manicouagan 5 (Quebec Hydro)	1,550,000 hp
Total	4,280,000 hp

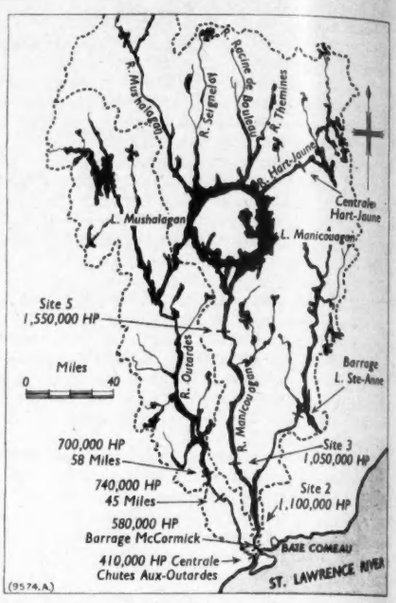
Each of the three sites, 2, 3 and 5 is situated above the Manicouagan's three major waterfalls (as may be gathered from the map). The 650 ft high dam will be built at Manicouagan 5, creating a reservoir, joining up the Mushalagan and Manicouagan lakes by lifting the water level so that it will hold 5 × 10^{12} cu. ft of water. The reservoir will cover an area of 800 square miles.

The circular shape of this reservoir, with a vast island in the centre, is shown on the map. It is believed that this reservoir will be the largest in the world after the Salte de Aldeadavilla watershed in Spain and the Kariba reservoir on the Zambesi. About eight years will be required to fill the reservoir to the designed level of 1,180 ft above sea level. A similar period will be required for construction of the dam and power station. Building of the reservoir, dam and power station will proceed concurrently, with the level of the accumulating water being maintained 50 ft below the height of the rising dam.

MULTI-ARCH DAM

The dam at Manicouagan 5 will be a buttressed multi-arch structure, 650 ft high from the foundations, 4,000 ft long, and with the base at the centre 600 ft wide. It is estimated that 2,500,000 cubic yards of concrete will be required. The buttresses of the main arch will be at 450 ft centres, and those of the other spans at 295 ft centres. The power plant will be incorporated into the base of the main arch and will comprise eight generating units of 200,000 hp each.

The Manicouagan 5 power station at the fifth series of waterfalls from the mouth of the river will benefit from a 505 ft drop of water. Its basic details are given in Table II.



Catchments of the Rivers Manicouagan and Outardes, and the proposed dam sites. Completion of Mancouagan 5 will cause Lakes Mushalagen and Manouagan to join as shown.

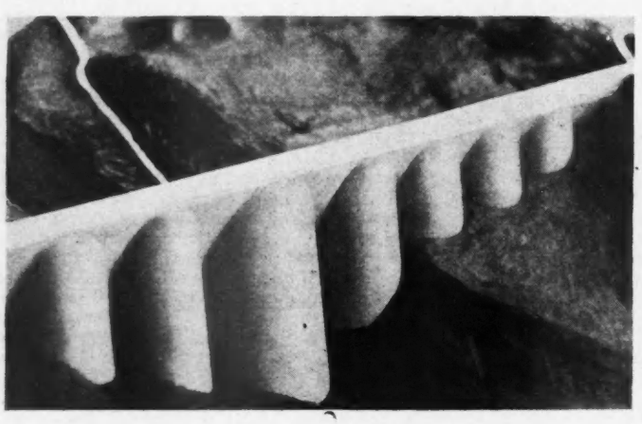
Manicouagan 5 is situated 126 miles upstream from the river mouth. Manicouagan 3 will be situated just above the third set of falls and about 50 miles from the river mouth. Here a rockfill dam will hold back about 350,000 million cu. ft of water at an elevation of 675 ft. An underground power station is planned with turbines operating under a 310 ft head of water. Basic details of Manicouagan 3 are shown in Table III.

Manicouagan 2 is located about ten miles from the river mouth at the second set of waterfalls. Ten generating groups of 110,000 hp each would give a total capacity of 1,100,000 hp. The power station will be above ground and the details of the plant are indicated in Table IV.

THE OUTARDES SCHEMES

Development of the Manicouagan river is to

A model of the Manicouagan 5 dam. (Below) The upstream face of the dam, and (right) the downstream face, with the power station between the two middle buttresses. With a length of 4,000 ft, the dam is thought to be the largest of its kind in the world. The power station is to house eight 200,000 hp turbo-generator units.



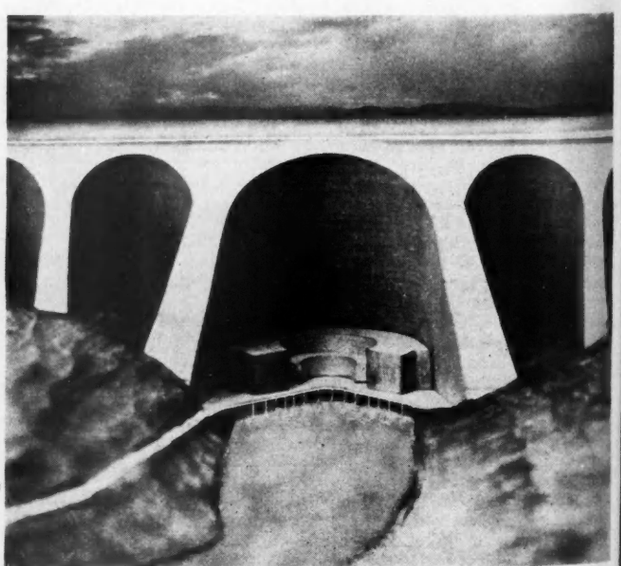


TABLE II:—*Details of Manicouagan 5 Power Plant*

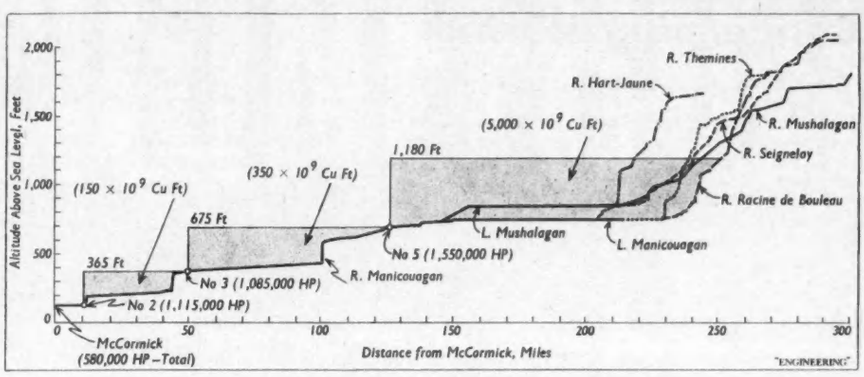
Drainage area	11,290 square miles
Controlled outlet	21,600 cu. ft per sec
Storage	5×10^{12} cu. ft
Elevation of reservoir	1,180 ft above sea leve
Elevation of outlet	675 ft
Drop or head of water	505 ft

TABLE III:—*Details of Manicouagan 3 Power Plant*

Drainage area	12,340 square miles
Controlled outlet	25,300 cusecs
Storage	350,000 million cu. ft
Elevation of reservoir	675 ft
Elevation of outlet	365 ft
Head of water	310 ft
Installation	1,050,000 hp from 7 generating sets of 150,000 hp each

TABLE IV :—*Details of Manicouagan 2 Power Plant*

Drainage area	17,550 square miles
Controlled outlet	36,000 cusecs
Upstream elevation	365 ft
Downstream elevation	125 ft
Head of water	240 ft



Longitudinal section of the Manicouagan scheme.

be the first stage of the whole project, followed by the harnessing of the Outardes. Surveys of the Outardes show that the river can handle large power installations at least at points 58 and 45 miles from the juncture with the St. Lawrence.

Outardes "58" generating station will have an installed capacity of 700,000 hp, under a 425 ft head of water. A storage dam will permit creation of a reservoir containing 650,000 million cu. ft of water at an elevation of 1,150 ft above sea level. Outardes "45" will have an installed capacity of 740,000 hp. The upstream level will be at an elevation of 725 ft and the downstream 300 ft, giving a 425 ft head of water. Also, by regulating the flow of the river at Outardes 58, the capacity of the Quebec North Shore Paper Company's power unit at Outardes Falls, near to the river mouth (see map), can be increased from its present 70,700 hp to 410,000 hp.

No decision has been made yet about transmission line voltage. The 6 million hp that will become available as the project is completed with other small power schemes under way or planned further west in the province, should take care of Quebec's power needs for the next 20 years. These estimates are based not only on population increases—Montreal could then be a city of nearly 3 million people against 2 million now—but also on possible mining, pulp and paper, aluminium and manufacturing industry requirements. Electric power is vital to all these activities, and at competitive rates, since the pipeline distance from Alberta makes natural gas more expensive than in Ontario and the West, and the cost of coal is high. The mining, aluminium and pulp and paper industries rely almost exclusively on electric power. Apart from a significant proportion of Canada's base metal output coming from Quebec, the south-eastern part of the province produces more than half of the free world's supply of asbestos.

Engineering skills for the Manicouagan and Outardes project will come mainly from Quebec Hydro itself, with several international firms of consultants likely to take part. Private contractors will carry out most of the work.

Transmission Towers Will Have to Look Better

The Central Electricity Generating Board have been experimenting to find out whether the high voltage transmission towers of the Grid and Supergrid might be specially painted to help them blend into the countryside.

Four 85 ft high towers on the 132 kV line between Oxford and Watford in the neighbourhood of Rickmansworth and Chenies were selected for treatment. They were chosen for the differing characters of their backgrounds, such as woods and hillsides, scrub and arable land. Painting was completed in March, 1960, so that the results could be studied in a winter setting and then, later, when the trees and vegetation were in full leaf.

A different experiment was tried on each tower. One was an all-over painting in dark bronze green. Another was painted similarly for the first 40 ft of its height, with the remainder of the tower treated in irregular patches of pink and blue. A third was painted in all-over irregular patterns of black, bronze green and pink. A matt paint was used throughout to avoid light reflection.

As had been foreseen, the major difficulty, particularly in the case of the towers which had been painted with a disruptive pattern, was that changing conditions of light and weather affected any attempt at all-out camouflage. A tower which was lost to view on an overcast day or beneath broken clouds showed up most markedly under a strong sun. The changing seasonal colours of the background had an equally nullifying effect. The tower painted black and green at the bottom with light blue and pink above to merge with the sky was almost invisible from half a mile away in one direction but conspicuous from another.

The broad conclusions drawn from these experiments were that the benefits to be obtained from the only practical forms of camouflage were, in fact, marginal, due to the varying conditions of light, viewpoint and seasonal background. In many cases a weathered and rusty tower was better than a painted one.

For the majority of conditions, weathered galvanised steel was still thought to be best, and when repainting becomes necessary an aluminium paint should be used. Against sky backgrounds in flat country, or where sea scapes were involved, a pale matt blue might be used. For heavy woodland and open moorland the dark bronze green was preferred. In well-timbered country, the natural break-up of rust against weathered galvanising seemed as acceptable as any form of painting.

The best general recommendation, comments the Board, seems to be to leave towers in their natural steel-grey colour and, when repainting becomes necessary, to use the British Standard dark bronze green which was recommended in the annual report of the Council for the Preservation of Rural England for 1958.

Nevertheless, because of their concern with preserving the amenities of the countryside, the Generating Board say they are likely to undertake further experiments on new transmission lines, particularly in areas of high amenity value.

A more general conclusion might be that, no matter what the circumstances, transmission towers cannot be hidden. Not everybody is offended by the sight of the towers, but as there appears to be no economic alternative, it looks as though future efforts will have to be concentrated on so improving the designs that the towers are as pleasing in appearance as possible to the majority.

Small Electrification Schemes also Play Their Part

Extension of electrification is probably being pursued in all countries of the world. Indeed the prospects for the manufacturers of all sorts of generation and transmission equipment is limited only by capital resources. The civil contractor, too, can expect a regular demand for his services in the construction of dams, power stations and associated works. Growth of demand throughout the world is rarely less than 10 per cent per annum and in some not-so-industrialised territories—Nigeria, for example—growth is around 22 per cent per annum.

A very large proportion of the World Bank loans are made in respect of electrical works. The Bank's recent loan of $8·8 million (£3 million) to Costa Rica is an example of their work in this field. The loan will help to finance the construction of a 30 MW hydro-electric plant on the Rio Macho, the establishment of 9 MW of diesel generating capacity in the principal area, and the extension of the central transmission network. The plant will increase by 40 per cent the supply to the Central Zone, which includes the capital, San José.

The second smallest of the Central American Republics, Costa Rica, has a population of about one million, and an area of under 20,000 sq. miles, about ten times that of Greater London. Income, *per capita*, is the highest of the Central American countries and there is a relatively even distribution of wealth. Estimates of energy demands show that there will be a growth of 11 per cent per annum for the next ten years. The loan has been made to the Instituto Costarricense de Electricidad (ICE), an autonomous government corporation, which owns and operates 52 per cent of the country's generating capacity and a transmission network.

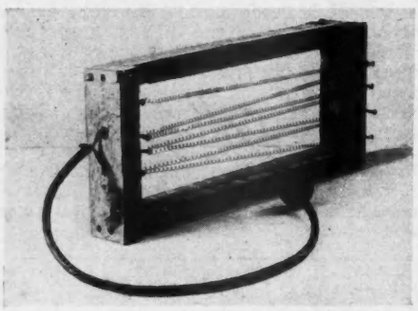
The hydro-electric plant on the Rio Macho will have an initial installed capacity of 30 MW, but the tunnels and other civil works will be arranged to allow for the future installation of up to 90 MW of generating capacity. In addition to this scheme and the diesel driven plant already mentioned, about 48 miles of new lines and associated substations will also be built.

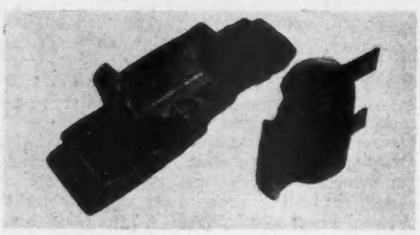
The total cost of the new facilities is put at around $18·5 million (£7 million). The Bank loan will cover foreign exchange requirements and the remaining costs will be met by the ICE from its own revenues, local borrowings and government contributions. International competitive bids will be called for in respect of the major equipment that will have to be imported.

Concerning Wiring

THERE is an old adage that the person who draws up his own will, or other legal document, thereby acting as his own lawyer, has a fool for his client. The same comment may well be applied in connection with the handyman who endeavours to do his own electrical installation work. A chief officer of a fire service recently expressed the opinion that the " do-it-yourself " habit can and does lead to grave dangers as far as electrical wiring is concerned.

Properly installed electric wiring and good quality electrical appliances made by a manufacturer of repute make the use of electricity in the home as safe as anything may be expected to be. The few accidents that do occur, arising from electric shock in homes, are generally due to lack of observance of simple precautions. By obeying a few simple rules the householder can reduce risks from electric shock, or from fire arising from faulty wiring, to a negligible degree. The following ten rules are simple common sense, but nevertheless are very often neglected.





(Above) Home made heaters can be unsafe—like this one. (Right) Old tobacco tins do NOT *make good junction boxes. (Below) The result of strapping a cartridge fuse with wire.*

1. Switch off appliances, particularly TV and radio sets, at the socket outlet or, if there is no switch at the socket, withdraw the plug.
2. Switch off before putting a lamp into a lampholder.
3. Never take a portable appliance or apparatus into the bathroom, and plug in your electric razor only to a proper shaver outlet.
4. Connect the electric iron to a socket outlet of adequate capacity and not to a lampholder at the ceiling pendant, table lamp or floor standard.
5. Withdraw the plug connection from an electric kettle before filling it with water.
6. Make sure that an efficient earth connection is provided for the cooker, washing machine, spin dryer, refrigerator or any other fixed or free standing appliance.
7. Do not use improvised or self-made heating or other appliances for domestic purposes.
8. Do not connect portable appliances by means of long trailing flexible leads and make sure the proper type of plug top is used to suit the socket. Flexible leads must not be run under carpets or lino or tacked to skirting boards or architraves. An adequate number of socket outlets is the proper answer.
9. Put off the main switch before replacing fuses in the control unit or fuseboard. Always use the proper size of fuse wire or cartridge fuse and never use fuse wire as a replacement for a cartridge fuse.
10. Do not carry out temporary or permanent extensions to an existing installation unless you are fully competent to do so.

Technical " know how," manipulative skill and experience are called for in installing electrical wiring and any substantial modification should be entrusted to an electrical contractor who is on the Roll of Approved Contractors maintained by the National Inspection Council for Electrical Installation Contracting. This is a voluntary, non-profit making body which not only inspects work done by a contractor seeking admission to the roll, but maintains a staff of trained Inspecting Engineers who periodically inspect the work of all approved contractors throughout the country. Such periodic inspection ensures that the Approved contractor employs only competent electricians, capable of carrying out their work to the standards required by the Institution of Electrical Engineers Wiring Regulations. These regulations lay down only " the minimum requirements to ensure freedom from fire and shock."

There are well over 5,000 names and addresses in the roll, located in all cities, towns and even villages throughout England, Scotland, Wales and Northern Ireland. The roll includes all contracting departments of the Electricity Boards and private contractors of all sizes, from the largest to the smallest concerns. A copy of the roll can be seen at all service centres of the local Electricity Board, and approved contractors enrolled with the Council can also be recognised by the red emblem with black and white lettering, which they display in their shops and showrooms and on their vans.

Electricity is being used to a greatly increasing extent for many domestic purposes. Some of the fixed wiring installations in domestic dwellings have been in service for at least 25 to 30 years and have only limited facilities for connecting the many and varied types of equipment which the householder needs. There is therefore some risk of serious overloading of the wiring contained in these older installations, and it is essential that they be periodically inspected and examined by a competent electrician.

The ten rules given above cover only the general day-to-day use of an electrical installation and the one golden rule covering all aspects is undoubtedly " Safety First."

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